THE EFFECT OF INCOME TAX REFORMS, ROYALTY REFORMS AND RELATIVE PRICE CHANGES ON POTENTIAL COPPER-ZINC PROJECTS IN MANITOBA

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by

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Abstract

The investment climate for copper-zinc projects in Manitoba worsened as a result of four distinct factors during the period from 1969 to 1977. These were: income tax reforms which led to increased federal and provincial tax assessments; a new provincial royalty act which resulted in increased royalty assessments for a profitable project; a jump in the annual rate of increase in capital and operating costs (inflation); and finally, copper and zinc price increases which failed to keep pace with the cost increases reflecting relatively long run changes in factors affecting world supply and demand. This study evaluates the effect of these factors on potential copper-zinc projects in the province. The analysis is undertaken using a computer model designed to calculate the optimum size of a project which would develop a given mineral deposit. The study shows that the private value of potential copper-zinc projects has declined by about 90 percent since 1969. Nearly two-thirds of this decline is attributed to increased tax and royalty assessments with the remainder a consequence of relatively depressed metal prices and inflation. The study also shows that from the province's point of view the income tax and royalty reforms have had some beneficial effects. In particular the new legislation has reduced the optimum private rate of ore extraction for a viable project closer to the socially optimum rate, resulting in an increase in overall benefits. The legislation is deficient where marginal projects are concerned in that a project will be unprofitable for a private firm even though it could generate some social benefits. Changes to the income tax legislation which would help alleviate this problem would be to allow preproduction development costs to be recovered immediately from a firm's income and include social

capital costs in the earned depletion bank. The royalty legislation could be improved by changing the fixed processing allowance to an investment allowance based on the undepreciated balance of total assets, increasing the rate at which investment could be recovered, and allowing losses to be carried forward. An unexpected deficiency in the existing royalty legislation in Manitoba is that it is not very effective in adjusting for inflation. Either more adequate indexing is needed or the two royalty rates should be replaced by a single rate. The study concludes that the worst feature of the reforms appears to be their timing. They were introduced when economic conditions were beginning to worsen, making the overall turn-down in the investment climate worse than it needed to be.

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For the errors and omissions that may remain, I accept full responsibility.

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Introduction

1.1 Background

The release of The Report of the Royal Commission on Taxation, The Carter Report, in 1967 marked the beginning of change in federal and provincial taxation policies applicable to the mining industry. By the mid-1960's, federal and provincial government incentives to mining companies in the form of tax exemptions and allowances had reached a maximum. With regard to federal corporate taxation, a depletion allowance of 33 1/3 percent of mining profits was automatic; new mine income was tax exempted for three years and, exploration and development could be recovered immediately from other mine income or as soon as income would permit. Provincial royalty assessments during this period were small, averaging less than 10 percent on mining profits, and in the case of Manitoba, were reduced by 50 percent on new mine income for a period of three years.

Because of these special provisions, the metal mining sector experienced one of the lowest effective corporate profits tax rates of any industry in Canada. The mining tax plus income tax as a percentage of book profit before taxes averaged 22.0 percent for Metal Mining over the period 1967-69.[1] The comparable rate for Manufacturing was 41.9 percent while the rate for All Industries was 32.9 percent.

In conjunction with the low level of taxation in the mining sector during the 1960's and strong metal prices, net earnings were well above the

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[1]Statistics Canada, 61-207, Corporation Financial Statistics, (Ottawa). The average effective tax rates for these sectors of the Canadian economy from 1967 to 1975 are shown in Appendix I to this chapter.

average for All Industries in Canada. In 1969 for example, the after-tax return to equity for Metal Mining was 12.33 percent while for All Industries it was 9.00 percent.[2] The above average rate of return in Metal Mining in combination with strong markets led to a high level of mine investment in Canada and an increase in mineral exploration and development in other parts of the world. This activity resulted in the creation of excess Canadian mine and processing capacity which became apparent as early as 1970 for nickel with mines in both Thompson, Manitoba and Sudbury, Ontario, being initially bought "on stream" and then placed on standby where they remain.

The relatively high returns to mining investment along with The Carter Report recommendations proposing major tax reform led to a noticeable change in the mining investment climate by the 1970's. "Winds of change"[3] were blowing that by 1974 had culminated in significant taxation changes federally as well as announced changed in provincial mining tax and royalty legislation in British Columbia, Saskatchewan, Manitoba and Ontario.

Federal changes included: (i) replacement of the three year tax holiday by an accelerated allowance for capital recovery; (ii) replacement of the automatic one-third depletion by an earned depletion system; and (iii) a limit on the rate at which preproduction development expenses could be recovered to 30 percent of the undepreciated cost.

Provincial changes were announced or implemented in several provinces. In British Columbia, an additional two-tiered royalty system was introduced in which the incremental royalty was tied to price changes in

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[2] Ibid. The net return to equity for these sectors of the Canadian economy from 1967 to 1975 are shown in Appendix II to this chapter.

[3] This is the sub-title of a tax and royalty summary for Canada published in 1974 by Price-Waterhouse & Co.

comparison to a moving average of past prices. In Saskatchewan it was announced that a potash reserve tax which would be based on world prices was to be introduced. In Manitoba, the royalty rate was increased from 15 percent to 23 percent pending the introduction of a new royalty system. In Ontario, new royalty rates were introduced which increased as profit increased and meant that large firms would normally be subject to higher average rates than small firms.

The mining sector, by way of the Mining Association of Canada, responded with three major objections to the new policies.[4] First the association argued that governments had not taken into account the unusual amount of risk facing the mining sector, which justified their receiving preferential tax treatment in relation to other sectors. Second the association pointed out the combined taxes and royalties could exceed the assessments on other sectors thereby leading to a dismantling of the mining sector. Third, the association argued that mining tax legislation which would slow the rate of resource development would not result in good conservation of mineral resources; it would only force Canadian-based mining companies to accelerate their exploration activity outside Canada. In the association view, accelerated development in other parts of the world in combination with higher costs of doing business in Canada would result in reduced Canadian production accompanied by fewer employment opportunities and a decline in exports.

The situation portrayed by The Mining Association of Canada in 1974 is becoming the reality of 1977 and 1978. Canada's share of world metal production is indeed falling; exports of refined metals have declined

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[4]The Mining Association of Canada, Supertax! The Impending Crisis in Canada's Mining Industry and How It Will Affect All Canadians, 1974.

contributing to an increased trade deficit and a weakened Canadian dollar; and, there have been significant employee lay-offs in the primary metal production sector. Yet these occurrences cannot be entirely attributed to the tax and royalty changes that were introduced in the early 1970's. A number of other factors have contributed to the poor performance of the mining sector. These include: (i) increased competition in nickel and copper production from "third world" countries in Africa, Central and South America, and Southeast Asia; (ii) reduced demand for minerals by Canada's main customer, the United States of America, following the Viet Nam War and a decline in spending for the space program; (iii) a desire by Canadian mining companies to increase investment in other countries in order to maintain their share of world production; (iv) the increased labour and energy costs experienced in the early 1970's; and (v) the creation of over capacity in the mining sector in the late 1960's because of the generous tax incentives in combination with a relatively high level of demand.

Thus world price increases for the metallic minerals failed to keep pace with cost increases for the Canadian industry. Although it could be argued that the desire by provincial governments for a larger share of mine profits encouraged mining company activity outside of Canada, the introduction of the revised legislation was coincident with the cost-price squeeze. That is, the adverse mining investment climate can be only partly attributable to the new mining tax and royalty legislation, with the remainder being attributable to the other factors referred to above as reflected in the relative price changes.

In addition to affecting the investment climate in the provinces, the income tax and royalty revisions along with the relative price changes also affect the potential mineral wealth of the provinces. This effect is not so obvious. It would be normal that increased taxes and royalties could result in some marginal projects no longer being profitable to a private developer. However, because such projects are not undertaken does not mean there is a significant loss of social benefits. Firstly, if the social benefits from a project amount to the surplus which will be generated (the revenue in excess of costs plus a return to the invested capital), the benefits lost because a marginal project is not undertaken are by definition small. Furthermore, the project may still be undertaken in the future when economic conditions warrant development. Secondly, even though a project can generate profits for a private developer, it may not generate benefits for society (or the province). The tax and royalty legislation in place may result in a project being profitable for a private developer to undertake, yet the surplus generated could be negligible (or even negative). Such a project, while profitable to a private developer, could be profitable because of subsidies from the tax system. This is a possibility whenever the net taxes and royalties generated are negative.

More important, however, is the way the potential mineral wealth of a province can be changed by the effect of the tax and royalty on the optimum production rates of potential projects. This is because the total profit from a mineral resource project is a function, not only of annual costs and prices, but also of the rate of ore extraction. A rational developer does not simply maximize annual profits, but because a deposit has a finite life maximizes instead the present value of the total resource. As this study will show, the optimum rate of ore extraction for a private developer usually differs significantly from the socially optimum rate (defined as the rate which will maximize the surplus). Although some of this difference can be attributed to the higher discount rate used by a private developer, it is also dependent on the income tax and royalty legislation in place. When a large, profitable deposit is mined at a rate which is too high or too low, the loss in potential wealth to society can be substantial.

1.2 Purpose of the Study

This study will evaluate the effect of income tax, royalty, and price changes on potential mining projects from two points of view. The first point of view is that of a mining firm maximizing the present value of the resource. The income tax and royalty regimes whose effects will be compared are those in force in Manitoba in 1969 (prior to any significant changes to the rates or method of calculating assessable profit) and those in force in 1977 (after the federal and provincial changes were nearly complete). Similarly, the costs and prices whose effects will be compared are those which existed in 1969 and again in 1977. In addition, the effects of the legislative changes will be compared with the effects of the cost and price changes and finally the combined effects of the price changes and legislative changes that occurred from 1969 to 1977 will be shown.

The second point of view is that of the province which would wish to maximize the surplus from a project. Again, a comparison will be made of the effects on projects because of changes to the income tax and royalty regimes as well as those resulting when costs and metal prices changed. As before the two points in time of concern are 1969 and 1977.

The study is limited to projects which would develop copper-zinc deposits in Manitoba. The reason for this is as follows. Of the present metallic mineral production in Manitoba only copper, nickel, and tantalum can be considered principal minerals; the others including zinc, gold, silver, the platinums, lead and selenium are essentially by-products. Tantalum is a rare metal of which one deposit exists in this hemisphere. A study of the effects of the mining tax and royalty legislation on tantalum profitability would be limited to the one project already in operation as it is highly unlikely other deposits will be discovered in the province. Nickel is sufficiently different from copper in terms of production costs and marketing to justify a separate study. Copper is chosen over nickel in that more information is available on project capital and operating costs, greater potential appears to exist for new copper-zinc discoveries, and the most promising areas for new discoveries are more widely held than is the case for nickel.

Three different size of projects are used in the analysis. The first project characterises small copper-zinc deposits of up to one million tons in size. Such a project would have to be undertaken by a nearby operating mine since it is too small to support the costs of a separate processing facility. Also, it would need to be located near existing social infrastructure if development is to take place. These assumptions are incorporated in the model used in the analysis as follows. Concentrating (by the nearby large mining firm) is done for a constant charge per ton of input. Concentrator capital costs are assumed to be zero. Social capital costs are one-half the total needed if the deposit were to be developed as a separate project. Capital costs are recovered from other mining income to the extent allowed in the income tax and royalty acts. Consequently the net cost to the firm is gross cost less the saving in taxes and royalties. Projects of this size are therefore sensitive to the nearness of social infrastructure and to the capital recovery provisions in the income tax and royalty legislation.

The second project would develop copper-zinc deposits in the one million to ten million ton range. Although this size of deposit is often marginal as an independent project, it can be easily undertaken by a mining company in the same region. The assumptions in the model for the second project are that social capital costs are half those necessary for an independent project and that capital costs can be recovered from other mine income. This project has a separate concentrator. As with the smaller project, the feasibility of this size of project is sensitive to the nearness of social infrastructure and to the capital recovery provisions in the income tax and royalty legislation.

The third project would develop copper-zinc deposits in the ten million to 100 million ton range. It is assumed that this project is fully independent in that all costs are recovered from any income generated after production begins. Projects of this size and quality are shown to be profitable for a private developer to undertake under a wide range of conditions.

The analysis is carried out by undertaking a series of feasibility tests (or experiments) on the three different copper-zinc deposits using a modified version of a computer model developed by the author within The Department of Mines, Natural Resources and Environment.[5] The computer model is initially provided with geological data on the deposit, capital and operating cost data applicable to the type of deposit being evaluated, metal prices, discount rates, and inflation rates. Then using the discounted cash flow a project would yield, the model, by way of an iterative process,

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[5] Bagnall, R., A Computer Model for Determining the Optimum Size of a Mine Project, Study financed jointly by the Federal and Provincial governments under the Non-Renewable Resource Evaluation Program agreement (project number NM7511-3).

determines the size and life of the project which would maximize the present-value of the deposit. Since the present-value is sensitive to the kind of taxes and royalty systems in effect, the discount rate used, and relative prices, a change in any one of these not only affects the present value but also results in a project whose characteristics are changed. That is, different amounts of capital would be invested, the amount of primary ore in the deposit would change, and the project would yield different amounts of profit, taxes, and royalties.

In order to measure the effects on a project of changes in income tax and royalty legislation, metal prices, and production costs from the point of view of a mining firm, eight experiments are used. Six experiments abstract from inflation while two include inflation. The first of the six experiments assumes 1969 income tax and royalty legislation, and 1969 prices and costs. After the characteristics of the optimum project that would develop each deposit are determined, successive experiments introduce the 1977 income tax legislation, 1977 royalty legislation and 1977 metal prices and costs, in turn and then together. Inflation for 1969 and 1977 is introduced to the experiments that depict 1969 and 1977 conditions respectively. Each experiment identifies: (i) the optimum annual production rate; (ii) the amount of ore in the deposit; (iii) the private value of the deposit; (iv) the social surplus generated; (v) the taxes and royalties generated, and; (vi) the optimum level of capital investment under the specified conditions.

In order to show the effects of the new tax and royalty legislation as well as changing prices on copper-zinc projects from the point of view of the province, seven experiments are used. The first experiment maximizes the present value of the gross profit cash flow, using the social opportunity cost as a discount rate. Subsequent experiments introduce the supply price of private capital as a discount rate, the 1969 income tax and royalty legislation, the 1977 income tax legislation, the 1977 royalty legislation, and then both pieces of legislation. The final experiment shows the effect on the socially optimum project when the 1969 metal prices and costs are replaced by those for 1977.

The results of the analysis shows that, from the point of view of a mining firm, the value of potential copper-zinc projects has dropped by nearly 90 percent in the period from 1969 to 1977. Nearly two-thirds of this decline is attributed to the changes in income tax and royalty legislation. The remaining one-third is attributed to a combination of the relative decline in metal prices and increased rates of inflation. Very small projects are rendered uneconomic both by the legislation and by depressed prices.

From the province's point of view, the analysis shows that the most significant factor affecting Manitoba's potential copper-zinc wealth has been the relative decline in prices. The new income tax and royalty legislation, on the other hand, has tended to increase this wealth as the optimum private production rates have been moved closer to the socially optimum production rates.

Finally, the analysis indicates that some changes to both the income tax and royalty systems are necessary if the maximum possible benefits are to be realized from the development of the province's mineral resources by private firms. Suggestions for changes are made in the final chapter.

APPENDIX I

COMPARISON OF EFFECTIVE TAX RATES

		1967	1968	1969	1970	1971	1972	1973	1974	1975
Metal Mining	: Profit[1]	494.6	552.2	652.1	883.3	513.9	335.5	1,272.8	1,512.0	847.5
	: Direct Taxes[2]	86.0	136.8	155.6	270.5	126.7	111.9	376.1	666.6	347.5
	: Tax Rate (%)	17.39	24.77	23.86	30.62	24.65	33.37	29.55	44.09	41.00
Manufacturing	: Profit	2,806.5	3,228.2	3,697.8	2,899.4	3,679.0	4,361.3	6,606.6	8,697.2	7,625.5
	: Direct Taxes	1,184.1	1,362.4	1,527.7	1,237.6	1,500.2	1,771.2	2,464.7	3,424.9	3,092.6
	: Tax Rate (%)	42.19	42.20	41.31	42.68	40.78	40.61	37.31	39.38	40.56
All Industries	: Profit	8,191.0	9,246.0	10,131.7	9,651.2	11,616.5	11,553.0	16,980.1	23,890.0	23,366.2
	: Direct Taxes	2,604.4	3,029.9	3,453.5	3,399.8	3,720.8	4,122.2	5,914.4	8,444.9	8,433.7
	: Tax Rate (%)	31.80	32.77	34.09	35.23	32.03	35.68	34.83	35.35	36.09

Source: Statistics Canada, 61-207, Corporation Financial Statistics.

Notes: 1. Profit is Net Profit (Before Taxes).

2. Direct taxes are income and mining taxes assessed on profits.

APPENDIX II

COMPARISON OF RATES OF RETURN

		1967	1968	1969	1970	1971	1972	1973	1974	1975
Metal Mining :	Net Profit	408.6	415.4	496.5	612.8	387.2	223.6	896.7	845.4	500.0
:	Equity	2,864.1	2,996.8	4,026.7	4,286.5	4,365.7	4,358.7	4,887.8	5,272.3	5,422.9
:	Rate of Return (%)	14.27	13.86	12.33	14.30	8.87	5.13	18.35	16.03	9.22
Manufacturing :	Net Profit	1,622.4	1,865.8	2,170.1	1,661.8	2,178.8	2,590.1	4,141.9	5,272.3	4,532.9
:	Equity	19,063.5	19,863.2	22,110.0	23,141.2	24,670.9	25,800.1	28,310.9	32,447.5	36,000.5
:	Rate of Return (%)	8.51	9.39	9.82	7.18	8.83	10.04	14.63	16.25	12.59
All Industries:	Net Profit	5,586.6	6,216.1	6,678.2	6,251.4	7,895.7	7,430.8	11,065.7	15,445.1	14,932.5
:	Equity	63,222.0	67,769.9	74,210.0	83,036.0	90,102.2	97,070.8	106,442.0	118,476.5	130,416.5
:	Rate of Return (%)	8.84	9.17	9.00	7.47	8.76	7.66	10.40	13.04	11.45

Source: Statistics Canada, 61-207, Corporation Financial Statistics.

Chapter 2

The Analytical Model

The analysis is carried out using a computer program which will determine the optimum size of the mining project that would develop each deposit. Basically the program is an algorithm which will calculate the present value of the cash flow generated over the life of a project. Coupled to this is a procedure for systematically adjusting the size and productive life of the project until such time as the present-value is at a maximum.

The three sizes of copper-zinc project used in the analysis are evaluated from two points of view. The first point of view is that of a private investor who would be undertaking the project using equity capital. The optimum project in this case is the one which yields the highest present value of the annual net cash flow using the supply price of capital (SPC) as a discount rate. The supply price of capital is the minimum acceptable return an investor would anticipate before advancing capital for the project.

The second point of view is that of the province which, ideally, would want to maximize the present value of the before-tax cash flow, using the social opportunity cost (SOC) as a discount rate. The social opportunity cost is the average before-tax rate of return capital can earn in the Province.[1]

2.1 Project Evaluation

The appraisal of capital expenditure for a mining project is no different from the appraisal of any other investment. The method uses the discounted cash flow for an investment in one of three possible ways.[2] First,

[1]These discount rates plus a third, the private opportunity cost, are discussed more fully in Chapter 3 when the actual values are determined.

[2]Edge, C. G., A Practical Manual on the Appraisal of Capital Expenditure (Hamilton, Ontario: The Society of Industrial and Cost Accountants of Canada, 1971).

if a single investment is being considered, the internal rate of return (IRR) for the cash flow is calculated and compared to the investor's minimum acceptable return. The investment is desirable if the IRR exceeds the investor's minimum.

Second, where there is more than one investment opportunity, then the cash flow from each can be present-valued using the investor's minimum acceptable return as a discount rate. The investment with the highest present value is preferred, so long as it is positive and the projects are of similar life.

Third, if a specific project or task must be undertaken, but it can be undertaken a number of ways, the initial investment can be expressed as an equivalent after-tax annual cost (using the appropriate discount rate) and added to the after-tax operating cost. The investment with the lowest total annual cost is the preferred one.

The appraisal method used in this study is the second. Since the model determines the optimum size of project to develop a mineral deposit, it compares variations of the project and chooses the one that yields the highest present value. The variation that yields the highest present value is the optimum project because the marginal investment is just able to earn the desired minimum acceptable return. If the last increment of investment earns more than the minimum return, then the present value of the cash flow would still not be at a maximum; if it earns less, then the present value would be reduced below maximum.

The annual cash flow from the point of view of a private investor is calculated as follows:

from: Sales Revenue

deduct: Operating Costs

deduct: Provincial Royalties

deduct: Income Tax

deduct: Capital Costs

gives: Cash Flow

The annual cash flow from the province's point of view is:

from: Sales Revenue

deduct: Operating Costs

deduct: Capital Investment

gives: Cash Flow

This cash flow will also be the annual social benefits so long as a full employment economy is assumed and there are no external costs or benefits.

The present value of the cash flow stream for a project is:

$$P.V. = \sum_{i=1}^{n} CF_i \cdot (e^r - 1)/re^{ri}$$

where r is the supply price of capital or the social opportunity cost, depending on the point of view taken. The discount factor gives the value at the beginning of the first period of a one-year funds flow payment made during the i^{th} year.[3] This method is preferred since assuming a continuous flow during a period is more realistic than assuming a single payment at the end of a period, particularly for the early years of a project.

There are three important simplifying assumptions concerning the annual cash flow. The first is that the average grade of the ore mined and milled is constant over the primary ore[4] production period. Although the

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[3] Stermole, F. J., Economic Evaluation and Investment Decision Methods (Golden, Colorado: Investment Evaluations Corporation, 1974), Chapter 15.

[4] The primary ore is that on which the investment decisions are based. The calculation of the cut-off grade which will determine the total amount of primary ore in a deposit includes a profit element. The secondary ore is that remaining as determined by a cut-off grade where revenue just equals cost.

computer model could undertake an evaluation using the assumption that the highest grade of ore would be mined first, the assumption of a constant average grade of ore mined is more realistic. First, it is not always possible to mine strictly from the highest grade of ore to the lowest grade as might be desireable in theory. Second, in practice metal recovery in the concentrator will be more efficient if an even grade of feed is maintained. Third, the assumption of constant average production grades is consistent with that actually observed in mine feasibility studies.

The second simplifying assumption is that the tons of ore mined and milled annually is constant over the life of the project. This is also consistent with observed practice in actual mine feasibility studies although in theory, a firm maximizing the present value of a mine project would prefer an annual production schedule which was highest in the first years of production and would decline gradually as the ore was mined.[5] However, again this may not be practical. First it may not be possible to vary the production rate as desired from one period to the next. For example, this could be the case if it was necessary to maintain an even flow of material to the concentrator to ensure an efficient recovery of metal. Second, and very important, there may be insufficient knowledge of what the mine and concentrator cost functions would be over time for a possible project, particularly when they are subject to change as production proceeds. Without this knowledge, any decline in the annual rate of production would be based on other considerations such as mine depth or the ore configuration.

The third simplifying assumption is that metal prices and operating

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[5] Scott, A. T., "The Theory of the Mine Under Conditions of Certainty" in Gaffney, M., ed., Extractive Resources and Taxation, (Milwaukee: The University of Wisconsin Press, 1967).

costs will remain constant in real terms. That is, the metals sold, whether by long term contract or in an open market, will realize the same real price over the productive life of the project. Similarly, real labour and energy costs, the major components of operating costs, will not change disproportionately during the life of the project. Again this assumption is consistent with usual practice in mine feasibility studies, if not in ex-post experience.

Although most of the analysis is carried out abstracting from inflation, inflation is introduced in two of the experiments to illustrate how a higher than normal rate of inflation can also adversely affect the investment climate.[6] The most important inflationary effect is the anticipated differential inflation in capital costs, operating costs and metal prices.

However, inflation is also important in the calculation of income taxes and royalties. With regard to taxes, capital cost allowances and the earned depletion allowance are based on historical costs rather than current costs. If there is inflation, the real value of the capital recovered is less than the cost of its replacement. Taxes are assessed on the inflationary difference leading to a lower rate of return on the replacement value of capital than might have been anticipated under the assumption of no inflation. A similar argument applies with regard to royalty assessments based on mine profit.

Finally inflation could also be important if debt financing is assumed. Just as the real value of a depreciation allowance may decline over time with inflation, the repayments of the principal for borrowed capital will decline in real value. Also, if the interest rate does not

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[6] See, Inns, G., Kalcov, G., Health, K., "Treatment of Inflation in Mine Evaluation", in IMM Transactions, January, 1974.

fully anticipate future inflation, the real cost of borrowing will be less than anticipated. Thus the effect of inflation may be to yield a larger return to equity than anticipated.

When inflation is assumed in the analysis, the computer program will automatically calculate discount rates which include the proper element of inflation. The inflationary discount rate is one which will discount an inflated cash flow to the same present value as would the real (or uninflated) discount rate when applied to the uninflated cash flow. For example, if the uninflated gross profit per period is CF_i and the real discount rate is r then the present value of the profit stream is:

$$\overline{P.V.} = \sum_{i=1}^{n} \frac{CF_i}{re^{ri}/(e^r - 1)}$$

If the profit stream is inflating at a constant rate k then there is some discount rate s which will yield the same present value as occurred with no inflation. That is

$$\overline{P.V.} = \sum_{i=1}^{n} \frac{ICF_i}{se^{si}/(e^s - 1)}$$

where ICF is the inflated profit stream. The same present value will be achieved in the following case.

$$\overline{P.V.} = \sum_{i=1}^{n} \frac{CF_i \cdot ke^{ki}/(e^k - 1)}{re^{ri}/(e^r - 1) \cdot ke^{ki}/(e^k - 1)}$$

With the profit stream inflating continuously at a rate k the inflationary discount rate s will be such that

$$\frac{se^{si}}{(e^s - 1)} = \frac{re^{ri}}{(e^r - 1)} \cdot \frac{ke^{ki}}{(e^k - 1)}$$

The computer program will determine s, given r and k, by an iterative process in which s is systematically changed until such time as the value of the left hand expression approximates the value of the right hand expression .

with the desired degree of precision.

A final assumption concerns the type of financing used for each of the three sizes of project in the study. Because interest on debt capital is a deductible expense in arriving at taxable income, the method of financing assumed can affect the rate of return for a project. Since the 1969 and 1977 income tax legislation treat interest payments in an identical manner the analysis is not weakened (as well as being simplified) if it is assumed that only equity capital is used. The computer model has the facility to handle the assumption of debt financing so that a debt-equity ratio and bank lending rate need to be specified in the input data. Also the results of any experiment will include references to the debt capital.

2.2 The Computer Model

Figure 2.1 is a simplified flow chart of the computer program used for the analysis.[7] Each of the major sections of the program is described below.

The data requirements for any experiment are provided on three option cards, three or more cost cards, and one or more mineral reserve cards.[8] The first option card will contain (i) the net smelter return per pound of copper in the concentrate, (ii) the debt-equity ratio (zero for this study), (iii) the supply price of private capital, (iv) the private opportunity cost, (v) the bank lending rate (not used in this study) and, (vi) the social opportunity cost. The second option card will indicate (i) the number of cost cards provided, (ii) the number of mineral reserve cards provided, (iii) how the deposit will be mined (by high-grading or by average-grading), (iv) if graphs

[7]A complete listing of the program is contained in Appendix I to this chapter.

[8]An example of one of the experiments is contained in Appendix II to this chapter.

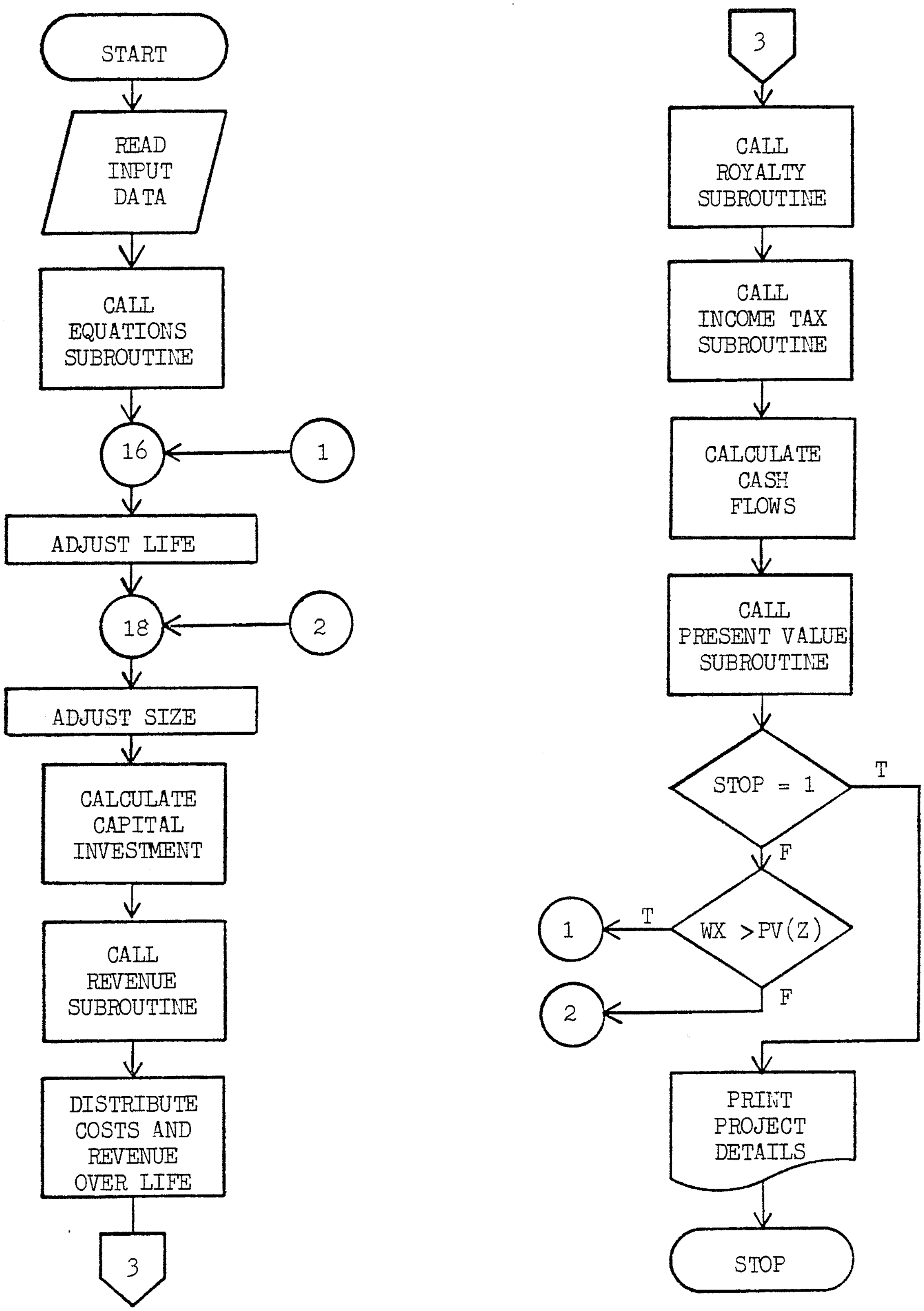

Figure 2.1 Simplified Flow Chart of Computer Model.

of the functions are to be printed, and (v) which cash flow is to be maximized. The third option card will show the rates of inflation (if any) for (i) capital costs, (ii) operating costs, and (iii) metal prices.

A minimum of three cost cards must be provided for any experiment. Each card will contain the appropriate capital and operating costs for a designated size of mine-concentrator facility. The capital costs are divided into five categories as required for an accurate determination of income tax and royalty liabilities. These are exploration, development, mine assets, processing assets, and service assets. The operating costs are for mining and concentrating. The data on the cost cards is used in the model to generate functions for each cost category. The independent variable in each case is annual capacity in tons of ore per year.

The mineral reserve card(s) will show (i) the average grade of the mineral shown on the card, (ii) the cut-off grade that was assumed for that quantity of mineral, and (iii) the tonnage of mineral in the deposit to which the grades apply. This data is used to generate two mineral reserve equations. The first equation is average grade as a function of the total amount of primary ore; the second is cut-off grade as a function of the primary ore.

The seven cost equations and two mineral reserve equations are determined in the EQUATN subroutine. Each set of cost data is tested with three different curves. One is linear, one is hyperbolic and one is log-linear. Using least-square techniques, the subroutine selects the function which will best fit the data. The mineral reserve equations are determined in one of two possible ways. If only a single data card is supplied, it is assumed that the grade-tonnage relationship for each of the equations is log-linear.[9] If three or more data cards are supplied, the mineral reserve equations are determined in the same manner as the cost equations. This subroutine will also print a graph of each of the functions if required.

After the nine equations are determined, the initial values for the preproduction period, size of project, and primary ore production period are assigned. Each will be one of three possible values depending on the size of the deposit being evaluated.

Once these initial steps are completed the model begins the iterative process which will determine the optimum project. First the capital investment is determined for the size of project being evaluated. Then each of five classes of capital is distributed evenly over the preproduction period. If inflation is a factor in the experiment, then the capital costs are inflated by the appropriate amount. Also introduced at this time are the assumptions concerning the projects which would develop the smaller two of the three deposits. For the smallest project this includes reduced service capital costs, no concentrator capital costs and a fixed charge per ton for concentrating. For the medium sized project it includes reduced service capital costs.

Second, the gross annual revenue for the productive life of the project is calculated in the REVENU subroutine. The mineral reserve functions, net smelter return value, and production period data are used by the subroutine to do this. Later the subroutine is called again to print the production details once the optimum project has been determined.

Third, the ongoing capital investments, working capital, salvage value (if relevant), and gross annual profit are determined and distributed

---

[9]See Musgrove, P. A., "Mathematical Aspects of the Grade-Tonnage Distribution of Metals", Appendix to, Brooks, D. B., "Mineral Supply as a Stock", in Vogely, W. A., ed., Economics of the Mineral Industries, (New York: American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., 1976).

over the productive life of the project. Ongoing capital investment in mining processing and social assets is calculated. Each is an annual fixed percentage of the initial investment for each category. The ongoing investment is assumed to take place only during the primary ore production phase. Working capital is calculated for the last year of the preproduction period and the first year of production. In each of those years it is a percentage of the total initial investment. For the final year of the project it is assumed that working capital recovery plus any salvage value is equal to the costs associated with the termination of the project.

Fourth, after the project is established, the anticipated royalties are calculated in the ROYALT subroutine. They are calculated according to the legislation as of 1969 or 1977, as required. This subroutine will also print the details of the royalty calculation for the optimum project.

Fifth, the anticipated income taxes for the project are determined in the INCTAX subroutine. Again they will be calculated according to the legislation as of 1969 or 1977. For the smaller two projects the net capital invested is determined taking into account the tax provisions which allow the immediate recovery of invested capital from other mining income. As in the ROYALT subroutine, the detailed tax calculations are printed after the optimum project is determined.

Sixth, after all costs and revenues have been determined, seven cash flows (or revenue flows) are determined. The computer program can be instructed to determine the project which would maximize the present value of any one of them.

The first is the project cash flow. As detailed in section 2.1 earlier, this is simply sales revenue less operating costs, provincial royalties, income taxes, and capital costs. When this cash flow is present-valued using the supply price of capital as a discount rate, the resulting value is the price that a private owner of the rights to the resource could ask if he were selling it to a similar person.

The second cash flow is calculated from the point of view of an equity investor when it is assumed that some of the invested capital is borrowed. This cash flow is determined by adding borrowed capital to the project cash flow and deducting debt repayment and interest costs. Valuing a project from the point of view of an equity investor can show the leverage effect of debt financing. This cash flow will not be used in the analysis since it is assumed that the project is financed with equity capital.

The third cash flow is the gross profit stream a project would yield. This is calculated in the model by adding back income tax and royalty payments to the project cash flow. The present value of the annual gross profits using the social opportunity cost as a discount rate gives the social surplus generated by the project. As mentioned earlier this will also be the social benefits assuming a full employment economy and no external costs or benefits.

The fourth cash flow is used to determine the economic rent the project will yield. The economic rent is the present value of the project cash flow, exclusive of annual royalty payments, using the supply price of capital as a discount rate. It is the maximum lump sum amount the province could charge a private developer for the rights to the mineral property. If a larger amount were asked for the rights, the developer would not be prepared to make the investment.

The fifth cash flow is used to determine the net social surplus from a project. The net surplus is the gross surplus less foregone taxes and royalties at the time of investment. Foregone taxes and royalties are calculated for the two smaller sizes of project since it was assumed the developer has other mining income which for tax purposes can be used to recover some or all investment as it is made.

The sixth revenue flow is the annual gross income taxes and royalties anticipated from a project. This revenue represents the direct benefits to the province that a project will generate after production begins. The stream of revenue is discounted to the present using the social opportunity cost as a discount rate.

The final revenue flow is the annual net taxes and royalties anticipated from the project. For the smaller two projects, the sixth revenue flow is reduced by the taxes and royalties foregone during the preproduction phase when the capital invested is being recovered from other income. As with the previous case, this revenue stream will be discounted to the present using the social opportunity cost as a discount rate.

Seventh, after the revenue flows have been determined, the present value of each is calculated in the PRVAL subroutine using the appropriate discount rate. As stated previously the present value of either the first or third revenue flows will be maximized in this study; the discount rates will be either the supply price of capital or the social opportunity cost respectively.

Once the evaluation is completed, and if the optimum project has not been determined, then either the size or the life of the project will be varied according to the results of the evaluation and the above sequence of events repeated. The procedure for arriving at the optimum project is illustrated by Figure 2.2. Basically the model will test a series of variations to a project and select that variation which will yield the highest present value for the revenue stream being maximized. From Figure 2.2, assume

Figure 2.2

Variations of Project Tested

Size S

S_6L_1						
S_5L_1	S_5L_2	S_5L_3				
S_4L_1	S_4L_2	S_4L_3	S_4L_4			
S_3L_1	S_3L_2	S_3L_3	*	S_3L_5		
S_2L_1	S_2L_2	S_2L_3	S_2L_4	S_2L_5		
S_1L_1	S_1L_2	S_1L_3	S_1L_4	S_1L_5		

0

Life L

that for the size of mineral deposit being evaluated, initial project size and life assigned is S_1L_1 at the origin 0. For life L_1, the size of the project is initially increased in steps of 16,384[10] tons of capacity per year. When the present value of the revenue stream can no longer be increased by additional increases in size, such as at S_6L_1, the life of the project is increased, initially by one year. Then the size incrementing begins again at S_1. Assuming project S_3L_4 yields the greatest value, a possible total of 23 different projects could have been tested. At this time the size and life increments are halved and a new origin established in the region of S_2L_3. A new optimum project is then determined followed by a further halving of the size and life increments. This procedure continues until the optimum project is determined to 1 ton of annual capacity. This degree of precision

[10] 16,384 is 2^{14}. Each time the optimum project is determined, the size and life increments are halved and a new optimum project determined. This procedure is repeated 14 times.

enables the model to measure the effects on the optimum project of very small changes to the discount rate or tax and royalty rates.

2.3 Experiments Performed in the Analysis

Eleven different experiments are performed on each project in the analysis. Since there are three sizes of project, a total of 33 experiments are carried out. They are listed in Table 2.1.

An Investor's Point of View

To evaluate the effects of the income tax, royalty, and price changes from the point of view of a private firm, experiments number 3, 4, 5, 6, 7, 9, 10, and 11 are used. Experiment number 3 establishes the optimum size of project for an investor given the conditions of legislation and prices in 1969. The discount rate is the real supply price of capital (inflation is excluded).

Table 2.1

Experiments Performed

Experiment	Discount Rate	Income Tax	Royalties	Prices	Inflation	Optimized
#1	S.O.C.	1969	1969	1969	No	Surplus
#2	S.P.C.	1969	1969	1969	No	Surplus
#3	S.P.C.	1969	1969	1969	No	Priv. Value
#4	I.S.P.C.	1969	1969	1969	Yes (1969)	Priv. Value
#5	S.P.C.	1977	1969	1969	No	Priv. Value
#6	S.P.C.	1969	1977	1969	No	Priv. Value
#7	S.P.C.	1977	1977	1969	No	Priv. Value
#8	S.O.C.	1969	1969	1977	No	Surplus
#9	S.P.C.	1969	1969	1977	No	Priv. Value
#10	S.P.C.	1977	1977	1977	No	Priv. Value
#11	I.S.P.C.	1977	1977	1977	Yes (1977)	Priv. Value

Experiment number 4 is the same as number 3 except that the relatively low rate of inflation for 1969 is introduced and the appropriate inflationary discount rate (I.S.P.C.) is used. These experiments are the basis for later comparison when the new tax and royalty legislation is introduced and when economic conditions change. Economic conditions are changed when metal prices do not increase as quickly as capital and operating costs and when the rate of inflation changes.

In experiment number 5 the income tax legislation as of the beginning of 1977 is introduced. The major changes from the 1969 legislation are: (i) the 3 year tax exemption is replaced by the immediate recovery from new mine income, of mining, processing, and social capital investment; (ii) the automatic depletion is replaced by earned depletion; (iii) the deductibility of provincial royalties is replaced by an automatic resource allowance, and (iv) preproduction development costs can be recovered from other mine income to the limit of 30 percent of the undepreciated cost (rather than being fully recoverable). The most important change to a private investor is the elimination of the 3 year tax holiday.

Experiment number 6 is carried out using the 1969 tax legislation and 1977 royalty legislation. The new royalty system does not have a 3 year period of one-half royalty rates, the three small royalty rates are replaced by two larger rates, the mine income brackets are not fixed but are a percentage of the undepreciated cost of mining and service investment, and, the basic mine income bracket is adjusted because of inflation. The most important changes for a private investor are the elimination of the 3 year period of reduced royalty rates and the high incremental royalty rate in the new system. Both changes significantly increase the level of royalty assessments.

Experiment number 7 replaces both the income tax legislation and the royalty legislation of 1969 with that in effect in 1977. The results of this experiment can be compared with the results from experiment number 3 in order to measure the full impact of the legislative changes on project profitability.

Experiment number 9 differs from experiment number 3 in that 1969 costs and prices are replaced by those of 1977. Capital and operating costs for 1977 are the 1969 values inflated by a factor determined from Statistics Canada 13-211, Fixed Capital Flows and Stocks. 1969 and 1977 metal prices are the market prices in effect at those times. Since copper and zinc price increases since 1969 have not kept pace with cost increases, project profitability is reduced. The results of this experiment can be compared with those of experiment number 7 in order to determine the factors which have affected profitability the most.

Experiment number 10 combines 1977 costs and prices with 1977 income tax and royalty legislation. The results of this experiment can be contrasted with those of experiment number 3 to show the full extent (exclusive of inflation) that project profitability has declined since 1969.

Experiment number 11 differs from experiment number 10 in that the relatively high rate of inflation for 1977 is included in the evaluation. When the results of this experiment are combined with those of experiment number 4, the effect on project profitability assuming inflation can be compared to the effects under the assumption of no inflation (experiments number 3 and number 10). The comparison will make it possible to measure the adverse effects of higher inflation on the investment climate.

The Province's Point of View

To evaluate the effects on copper-zinc projects of the new income tax legislation, new royalty legislation, and price changes from the province's point of view, experiments number 1, 2, 3, 5, 6, 7, and 8 are used. The province's concern will be to maximize the surplus from a project. This surplus will accrue to the federal and provincial governments in the form of taxes and royalties and to private investors in the form of net profits. It is assumed that profits are reinvested or spent in the province and that federal taxes eventually benefit the province so that the province's concern will be the same as those of "society".

Experiment number 1 establishes what the rovince would consider to be the optimum size of project. This experiment maximizes the present value of the gross profit using the social opportunity cost as a discount rate. The size of project determined by this experiment will not only yield the maximum possible surplus, the amount of primary ore will be at a maximum while the amount of investment capital required will be at a minimum.

Experiment number 2 differs from experiment number 1 in that the discount rate used is the supply price of capital. The results of this experiment can be used to measure the effects on a project of using a discount rate which is above the socially optimum rate (as is the appropriate supply price of capital determined for this study). The general effect will be to cause the level of investment and annual rate of production to increase while the surplus and amount of primary ore decreases.

In experiment number 3 the effects of the 1969 income tax and royalty legislation on project characteristics are shown. Now the value of the project to a private investor is maximized. The general effect of the legislation will be to further increase the level of investment and annual rate of production and reduce the available surplus and amount of primary ore.

Experiment number 5 introduces the 1977 system of income taxes. Since the level of taxation is greater, mainly as a consequence of eliminating the three year tax holiday, the value of a project to a private developer will decline. However, from the province's point of view, if the rate of ore extraction is reduced and moved closer to the socially optimum rate, the result will be to increase the surplus and the amount of primary ore determined for the deposit. Of course, this assumes that the project is still sufficiently profitable for a private investor to undertake or that the province would develop any deposit a private firm would now decline to invest in.

In experiment number 6, the 1969 royalty system is replaced by that in effect as of 1977. Because of the high incremental royalty rate in the new system the optimum annual rate of production will be reduced[11] although the three year tax holiday in the 1969 income tax system will tend to offset this. To the extent that the rate of production is moved closer to the socially optimum rate the surplus available should be increased.

Experiment number 7 is carried out with both the 1977 income tax and 1977 royalty legislation. Because of the elimination of the three year tax holiday plus addition of the high incremental royalty rate, the level of investment and annual rate of production will be significantly reduced from their 1973 values. However if these values are moved closer to the socially optimum rates, the surplus and amount of primary ore determined for the deposit will likely be increased.

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[11] Ciriacy-Wantrup, S. V., "Taxation and the Conservation of Resources", in The Quarterly Journal of Economics, February, 1944.

Experiment number 8 is identical to experiment number 1 except that 1977 prices and costs are used. The increased costs in relation to metal prices are the main factors that will have the greatest adverse effect on the projects from the province's point of view.

As the analysis will show, the effects of the tax and royalty changes will differ, depending on the point of view taken. The results of the experiments should provide some guidelines as to the kind of legislation that is desirable, and the kind of legislation to be avoided. They will also show which of the economic and legislative factors that have changed since 1969 has had the greatest impact on the investment climate in the province.

APPENDIX I

COMPUTER MODEL LISTING

```
C A COMPUTER PROGRAM FOR DETERMINING THE OPTIMUM LEVEL OF INVESTMENT
C FOR A MINING PROJECT
C
C .................................................................
C PROGRAM DESIGN BY ROBIN G. BAGNALL
C DEPARTMENT OF MINES NATURAL RESOURCES AND ENVIRONMENT
C 975 CENTURY STREET, WINNIPEG MANITOBA
C TELEPHONE (204) 633-9543
C .................................................................
C
C THE MAIN PROGAM CACULATES THE PROJECT CASH FLOWS AND CONTAINS THE
C OPTIMIZING PROCEDURE.
C
        REAL*8 CAPCOS(10,8),GROPRO(50),U,BORCAP(50),DFLOAT,V,VALUE,AA(7),
     *SIZE,WX,YX,DLOG,COST(7),WORCAP(50),TOTROY(50),TOPCOS,BB(7),SM,SC,
     *TAX(50),INTRST(50),MAXTON,PRIN(50),DEXP,CASFLO(8,50),YY/1.D0/,
     *S,CAPTAX(50),SIZZ(50),PV(8),DER,DX,XR,TAPCOS,TL,BORROW,T,OH,TONS,
     *TOTCOS,EQUIT,DV/1.D0/,TTONS,ECOR,EQUI,TOTINV(50),OLDPV/-1.D+10/,
     *EXPLOR(2,50),PREPRO(2,50),MININV(2,50),PROINV(2,50),SOCINV(2,50),
     *RI,RJ,RK,BG/02.D0/,PVAL,NSUR,GTAX,NTAX,VP,GROINV(50),FORGON(50),
     *A(7),B(7),AK,MINRAL(10,8)/80*0.D0/,GSUR,REVENU(50),G/16384.D0/,
     *INFLA1(50),INFLA2(50),INFLA3(50)
      INTEGER H(7),C,LIFE,MBL/5/,NIT/0/, HH(7),D,E, STOP/0/,IC,
     *CBL/10/,LIF1,Z, P/7/,PP/2/,PG,HG,LET/0/,IOP
      COMMON GROPRO,MININV,PROINV,EXPLOR,SOCINV,PREPRO,TOTROY,TAX,
     *CAPTAX,WORCAP /B1/INFLA2/B2/T,RI/B3/TL/B4/INTRST,PRIN,U
     */B5/BORCAP,DER,SM,SC/B6/INFLA3,SIZZ,REVENU,A,B,VALUE,TOPCOS
     */B7/CASFLO,PV,S,V,IC/B8/HH,LIFE/B9/IY/B12/HG,IOP/B0/C,D,N//IQ
C
C READ AND PRINT INPUT DATA.
C
      READ 01,VALUE,DER,S,T,U,V,L,M,HG,PG,Z
01    FORMAT(F8.5,2X,5F10.5,/,5(I2,3X))
      READ 02,RI,RJ,RK
02    FORMAT(3F10.5)
      READ 03,((CAPCOS(I,J),J=1,8),I=1,L)
03    FORMAT(5F12.0,2F5.2,F10.0)
      READ 04,((MINRAL(I,J),J=1,3),I=1,M)
04    FORMAT(3F15.5)
      PRINT 05
05    FORMAT('1',//,40X,'INPUT DATA',/,'+', 39X,10('_'))
      PRINT 06,VALUE,DER,S,T,U,V,L,M,HG,PG,Z,RI,RJ,RK,
     *((CAPCOS(I,J),J=1,8),I=1,L)
06    FORMAT(//,40X,     'THREE OPTIONS CARDS',//,20X,6F10.5,//,
     *22X,5(I2,3X),//,20X,3F10.5,
     *              ////,40X,'COST CARDS',//,((5F12.0,2F5.2,F10.0)/))
      PRINT 07,((MINRAL(I,J),J=1,3),I=1,M)
07    FORMAT(/,40X,'MINERAL RESERVE DATA',//,3(20X,3F15.5,//))
C
C CALCULATE THE SEVEN COST FUNCTIONS AND THEN THE TWO MINERAL RESERVE
C FUCTIONS.
C
      CALL EQUATN(CAPCOS,L,AA,BB,H,P,PG)
      CALL EQUATN(MINRAL,M,A,B,HH,PP,PG)
      VP=1.D-15
C
C CALCULATE INFLATION INDEXES FOR THE FUTURE.
C
      DO 08 I=1,50
      INFLA1(I)=(RI*DEXP(RI*DFLOAT(I))+VP)/(DEXP(RI)-1.D0+VP)
      INFLA2(I)=(RJ*DEXP(RJ*DFLOAT(I))+VP)/(DEXP(RJ)-1.D0+VP)
```

```
08     INFLA3(I)=(RK*DEXP(RK*DFLOAT(I))+VP)/(DEXP(RK)-1.D0+VP)
C
C CALCULATE INFLATIONARY DISCOUNT RATES (IF APPROPRIATE).
C
       CALL RATE(S,T,U,V,RI)
       PRINT 11
11     FORMAT('1',//,51X,'PROJECT ITERATIONS',/,'+',50X,18('_'),//,
      *27X,'PREPRODUCTION',04X,'YEARS OF',18X,
      *'PROJECT',09X,'PRESENT',/,30X,'PERIOD',08X,'ORE LIFE',04X,
      *'MULTIPLIER',04X,           'CAPACITY',09X,'VALUE')
C
C USING THE MINERAL RESERVE FUNCTIONS DETERMINE THE MAXIMUM SIZE FOR
C THE DEPOSIT.
C
       IF(HH(2)-2)12,13,14
12     MAXTON=-A(2)/B(2)
       GO TO 15
13     MAXTON=-B(2)/A(2)
       GO TO 15
14     MAXTON=DEXP(-A(2)/B(2))
15     CONTINUE
C
C DETERMINE INITIAL VALUES FOR THE PROJECT SIZE,THE PROJECT PRODUCTION
C PERIOD AND THE VALUE FOR THE PREPRODUCTION PERIOD.
C
       LIF1=1
       IF(MAXTON.GT.1.0D+06)LIF1=2
       IF(MAXTON.GT.1.0D+07)LIF1=3
       AK=30000.D0
       IF(MAXTON.GT.1.0D+06)AK=410000.D0
       IF(MAXTON.GT.1.0D+07)AK=4000000.D0
       C=3
       IF(MAXTON.GT.1.0D+06)C=4
       IF(MAXTON.GT.1.0D+07)C=5
       D=C-1
       E=C+1
       VP=0.0223D0
       IQ=0
C
C FOR DEPOSITS LESS THAN 10 MILLION TONS 'IQ' IS SET EQUAL TO ONE SO
C THAT THE COSTS DETERMINED BY THE MODEL CAN BE MODIFIED IN A MANNER
C CONSISTANT WITH THE ASSUMPTION THAT  DEVELOPMENT IS BEING CARRIED OUT
C BY A NEARBY MINING FIRM.
C
       IF(MAXTON.LE.1.0D+07)IQ=1
C
C SET THE NUMBER OF CASH FLOWS.
C
       IC=7
C
C SO LONG AS 'IOP' IS ZERO  ONLY THE PRIMARY ORE IS USED  IN THE
C OPTIMIZING PROCEDURE.
C
       IOP=0
C
C BEGIN THE ITERATIVE PROCESS TO DETERMINE THE OPTIMUM PROJECT.
C
77     MET=0
       XR=-1.0D+10
C
C INCREASE THE PRIMARY ORE PRODUCTION PERIOD BY ONE UNIT.
C
```

```
16    LIF1=LIF1+1
      MET=MET+1
C
C INITIALIZE THE PROJECT SIZE.
C
      SIZE=AK
17    LET=0
      IW=0
      WX=-1.0D+10
C
C INCREMENT THE ANNUAL CAPACITY BY A DESIGNATED NUMBER OF TONS CAPACTY.
C
18    SIZE=SIZE+G
      LET=LET+1
C
C CALCULATE THE QUANTITY OF PRIMARY ORE.
C
19    TTONS=(SIZE*DFLOAT(LIF1))/DV
      NIT=NIT+1
C
C CALCULATE THE NUMBER OF FULL YEARS OF PRIMARY ORE PRODUCTION.
C
      LIFE=LIF1/DV
      N=D+LIFE
      DO 32 I=C,N
32    SIZZ(I)=SIZE
C
C CALCULATE THE AMOUNT OF PRIMARY ORE IN THE LAST YEAR OF PRODUCTION.
C
      TONS=LIFE*SIZE
      TL=TTONS-TONS
      IF(TL.LE.0.D0)GO TO 33
      N=N+1
      SIZZ(N)=TL
33    CONTINUE
C
C CALCULATE THE CAPITAL AND OPERATING COSTS FOR THE SIZE OF PROJECT.
C
      DO 20 K=1,7
      IF(H(K)-2)21,22,23
21    COST(K)=AA(K)+BB(K)*SIZE
      GO TO 20
22    COST(K)=AA(K)+BB(K)/SIZE
      GO TO 20
23    COST(K)=AA(K)+BB(K)*DLOG(SIZE)
20    CONTINUE
C
C MODITY THE COSTS AS APPROPRIATE FOR THE TYPE OF PROJECT.
C
      IF(MAXTON.GT.1.0D+07)GO TO 25
      COST(5)=0.5D0*COST(5)
      IF(MAXTON.GT.1.0D+06)GO TO 25
      COST(4)=0.D0
C
C THIS VALUE IS PECULIAR TO THE STUDY BEING UNDERTAKEN.
C
      COST(7)=0.5D0*CAPCOS(3,7)
25    CONTINUE
C
C DISTRIBUTE THE CAPITAL COSTS OVER PREPRODUCTION PERIOD.
C INFLATE THE CAPITAL COSTS BY THE APPROPRIATE INFLATION INDEX.
C
```

```
      DO 24 I=1,D
      WORCAP(I)=0.D0
      GROPRO(I)=0.D0
      SIZZ(I)=0.D0
      EXPLOR(1,I)=COST(1)/D*INFLA1(I)
      EXPLOR(2,I)=EXPLOR(1,I)
      PREPRO(1,I)=COST(2)/D*INFLA1(I)
      PREPRO(2,I)=PREPRO(1,I)
      MININV(1,I)=COST(3)/D*INFLA1(I)
      MININV(2,I)=MININV(1,I)
      PROINV(1,I)=COST(4)/D*INFLA1(I)
      PROINV(2,I)=PROINV(1,I)
      SOCINV(1,I)=COST(5)/D*INFLA1(I)
24    SOCINV(2,I)=SOCINV(1,I)
C
C CALCULATE THE OPERATING COSTS FOR THE SERVICE ASSETS.
C
      OH=0.15D0*(COST(6)+COST(7))
      TOPCOS=COST(6)+COST(7)+OH
C
C CALCULATE THE ANNUAL GROSS REVENUE THE PROJECT WILL GENERATE.
C
      CALL ANNREV
C
C CALCULATE THE WORKING CAPITAL FOR THE PROJECT.
C
      TOTCOS=COST(1)+COST(2)+COST(3)+COST(4)+COST(5)
      WORCAP(D)=0.10D0*TOTCOS*INFLA2(D)
      WORCAP(C)=0.15D0*TOTCOS*INFLA2(C)
      DO 34 I=E,N
34    WORCAP(I)=0.D0
C
C CALCULATE THE SALVAGE VALUE OF MINING AND PROCESSING ASSETS.
C THE SALVAGE VALUES WILL BE SET EQUAL TO ZERO FOR THIS STUDY.
C
      SM=0.D0
      SC=0.D0
      IF(IOP.NE.2)GO TO 30
      SM=DFLOAT(MBL-N+D)/DFLOAT(MBL)*COST(3)/2.D0*INFLA1(N)
      IF(SM.LT.0.D0)SM=0.D0
      SC=DFLOAT(CBL-N+D)/DFLOAT(CBL)*COST(4)/2.D0*INFLA1(N)
      IF(SC.LT.0.D0)SC=0.D0
      WORCAP(N)=-0.25D0*TOTCOS*INFLA2(N)-SM-SC
30    CONTINUE
C
C CALCULATE THE ONGING INVESTMENT DURING THE PRIMARY ORE PRODUCTION.
C
      DO 35 I=C,N
      BORCAP(I)=0.D0
      EXPLOR(1,I)=0.D0
      EXPLOR(2,I)=0.D0
      PREPRO(1,I)=0.D0
      PREPRO(2,I)=0.D0
      TL=SIZZ(I)/SIZE
      IF(IOP.EQ.1.AND.I.EQ.(N-IY))TL=YY
      IF(I.LE.(N-IY))GO TO 36
      MININV(1,I)=0.D0
      MININV(2,I)=0.D0
      PROINV(1,I)=0.D0
      PROINV(2,I)=0.D0
      SOCINV(1,I)=0.D0
      SOCINV(2,I)=0.D0
```

```
      GO TO 35
36    MININV(1,I)=COST(3)*0.025D0*INFLA1(I)*TL
      MININV(2,I)=MININV(1,I)
      PROINV(1,I)=COST(4)*0.015D0*INFLA1(I)*TL
      PROINV(2,I)=PROINV(1,I)
      SOCINV(1,I)=COST(5)*0.020D0*INFLA1(I)*TL
      SOCINV(2,I)=SOCINV(1,I)
C
C CALCULATE THE GROSS PROFIT FOR THE PROJECT.
C
35    GROPRO(I)=REVENU(I)-TOPCOS*SIZZ(I)*INFLA2(I)
      TL=SIZZ(N)/SIZE
C
C CALCULATE THE ROYALTIES THE PROJECT CAN ANTICIPATE.
C
      CALL ROYALT
C
C CALCULATE THE INCOME TAXES THE PROJECT CAN ANTICIPATE.
C
      CALL INCTAX
      DO 37 I=1,N
C
C CALCULATE THE FOREGONE TAXES AND ROYALTIES AT THE TIME OF INVESTMENT.
C
      TOTINV(I)=MININV(2,I)+PROINV(2,I)+EXPLOR(2,I)+SOCINV(2,I)+
     *PREPRO(2,I)
      GROINV(I)=MININV(1,I)+PROINV(1,I)+EXPLOR(1,I)+SOCINV(1,I)+
     *PREPRO(1,I)
      FORGON(I)=GROINV(I)-TOTINV(I)
C
C CALCULATE THE SEVEN REVENUE FLOWS FOR THE PROJECT.
C
      CASFLO(1,I)=GROPRO(I)-TAX(I)-CAPTAX(I)-TOTROY(I)-TOTINV(I)-
     *WORCAP(I)
      CASFLO(2,I)=CASFLO(1,I)-INTRST(I)-PRIN(I)+BORCAP(I)
      CASFLO(3,I)=CASFLO(1,I)+TAX(I)+TOTROY(I)+CAPTAX(I)
      CASFLO(4,I)=CASFLO(1,I)+TOTROY(I)
      CASFLO(5,I)=CASFLO(3,I)-FORGON(I)
      CASFLO(6,I)=TAX(I)+TOTROY(I)+CAPTAX(I)
37    CASFLO(7,I)=CASFLO(6,I)-FORGON(I)
C
C CALCULATE THE PRESENT VALUE OF EACH OF THE REVENUE FLOWS.
C
      CALL PRVAL
      IF(TL.EQ.1.D0)TL=0.D0
      IF(TL.GT.0.D0)LIFE=N-C
C
C IF THE OPTIMUM PROJECT HAS NOT BEEN DETERMIMED CONTINUE THE OPTIMIZING.
C
      IF(STOP.EQ.1)GO TO 46
C
C RECORD THE PROJECT PARAMATERS FOR THE PRIMARY ORE FROM THE OPTIMUM PROJECT.
C
      IF(DV.NE.16384.D0.OR.PV(Z).LT.XR)GO TO 39
      PVAL=PV(1)
      EQUI=PV(2)
      GSUR=PV(3)
      ECOR=PV(4)
      NSUR=PV(5)
      GTAX=PV(6)
      NTAX=PV(7)
39    CONTINUE
```

```
C
C IF THE CURRENT VARIATION OF THE PROJECT IS NOT AN IMPROVEMENT,
C DO NOT RECORD IT'S SIZE AND PRODUCTION PERIOD.
C
      IF(PV(Z).LT.XR)GO TO 40
      IW=1
      YX=SIZE
      LL=LIF1
      DX=DV
      XR=PV(Z)
40    CONTINUE
C
C IF THE SIZE OF THE PROJECT HAS BEEN INCREASED BY ONLY ONE UNIT OF SIZE,
C RECORD THE PRESENT VALUE OF THE REVENUE STREAM BEING MAXIMIZED.
C
      IF(LET.EQ.1)OLDPV=PV(Z)
C
C IF ONLY TWO SIZE VARIATIONS OF THE PROJECT HAVE BEEN TESTED,
C AND NO FURTHER IMPROVEMENT IS POSSIBLE BEGIN THE SIZE INCREMENTING
C FROM A SMALLER INITIAL VALUE.
C
      IF(LET.EQ.2.AND.OLDPV.GT.PV(Z))GO TO 41
      GO TO 42
41    SIZE=SIZE-G*4.D0
      IF(DV.GT.2.D0)SIZE=SIZE-G*8.D0
      GO TO 17
42    CONTINUE
C
C IF SIZE INCREMENTING IS TAKING PLACE AND NO FURTHER IMPROVEMENT IS
C POSSIBLE BYPASS THE SERIES OF STEPS PERTAINING TO THE LIFE ADJUSTMENT.
C
      IF(IW.EQ.0.AND.WX.GT.PV(Z))GO TO 43
C
C IF THE CURRENT VARIATION OF PROJECT IS NOT AN IMPROVEMENT TRANSFER TO
C WHERE THE LIFE CAN BE INCREASED BY ONE UNIT.
C
      IF(WX.GT.PV(Z))GO TO 16
C
C RECORD THE NEW PRESENT VALUE AND TRANSFER TO WHERE THE SIZE CAN BE
C INCREASED BY ONE INCREMENT.
C
      WX=PV(Z)
      GO TO 18
43    CONTINUE
C
C IF AT LEAST ONE VARIATION IN PROJECT LIFE HAS BEEN TESTED THEN PROCEED
C TO WHERE THE SIZE AND LIFE INCREMENTS WILL BE REDUCED IN MAGNITUDE.
C OTHERWISE REDUCE THE INITIAL LIFE VALUE BY TWO UNITS AND BEGIN AGAIN.
C AN OPTION IS TO CHANGE '.LE.1' TO '.GT.2' TO ENSURE THAT THE LIFE VALUE
C IS OPTIMUM.
C
      IF(MET.GE.1)GO TO 44
      LIF1=LL-2
      GO TO 77
44    CONTINUE
C
C IF THE PROJECT SIZE INCREMENTS ARE REDUCED TO ONE, PROCEED TO WHERE
C THE FINAL OPTIMUM PROJECT SIZE AND LIFE VALUES ARE ASSIGNED.
C
      IF(G.EQ.1.D0)GO TO 45
C
C INITIALIZE THE PROJECT SIZE BELOW THE CURRENT OPTIMUM.
```

```
C
      AK=YX-G*02.D0
      G=G/BG
C
C INITIALIZE THE PROJECT LIFE BELOW THE CURRENT OPTIMUM.
C
      LIF1=LL-1
      LIF1=LIF1*BG
      DV=DV*BG
C
C PROCEED TO WHERE THE OPTIMIZING PROCEDURE CAN BEGIN AGAIN.
C
      GO TO 77
45    STOP=1
      LIF1=LL
      SIZE=YX
      DV=DX
      YY=SIZZ(N)/SIZE
      IF(IOP.EQ.0)IOP=1
C
C PROCEED TO CALCULATE THE PARAMETERS OF THE OPTIMUM PROJECT (INCLUDING
C TOTAL ORE).
C
      GO TO 19
46    CONTINUE
C
C BEGIN PRINTING THE RESULTS FOR THE OPTIMUM PROJECT.
C
      PRINT 47,NIT
47    FORMAT('1',///,40X,'NUMBER OF ITERATIONS',I10)
      PRINT 48
48    FORMAT('1',39X,  'DETAILED DATA FOR OPTIMUM RETURN',/,
     *'+',39X,32('_'),//,48X,'PRODUCTION DATA',/,'+',47X,15('_'),//)
      CALL PRNPRO
      S=S*100.0D0
      T=T*100.D0
      U=U*100.D0
      V=V*100.D0
      PRINT 49
49    FORMAT('1',//,44X,'ECONOMIC SUMMARY',/,'+',43X,16('_'))
      WORCAP(D)=WORCAP(D)/INFLA2(D)
      TAPCOS=TOTCOS+WORCAP(D)
      PRINT50,(COST(I),I=1,5),WORCAP(D),TAPCOS,COST(6),COST(7),OH,TOPCOS
50    FORMAT('-',38X,'EXPLORATION COSTS',F15.5,/,25X,'PREPRODUCTION DEVE
     *LOPMENT COSTS',F15.5,/,
     *39X,'MINING INVESTMENT',F15.5,/,35X,'PROCESSING INVESTMENT',
     *F15.5,/,31X,'SOCIAL CAPITAL INVESTMENT',F15.5,/   ,27X,
     *'PREPRODUCTION WORKING CAPITAL',F15.5,/,'+',55X,15('_'),/,
     *37X,'GROSS CAPITAL COSTS',
     *          F15.5,//,36X,'MINING COSTS PER TON',F15.5,/,35X,
     *'PROCESS COSTS PER TON',F15.5,/,28X,'ADMINISTRATIVE COSTS PER TON'
     *,F15.5,/,'+',55X,15('_'),/,51X,'TOTAL',F15.5)
      WORCAP(D)=WORCAP(D)*INFLA2(D)
      BORROW=TAPCOS*DER
      EQUIT=TAPCOS-BORROW
      PRINT51,DER,EQUIT,BORROW
51    FORMAT(//,39X,'DEBT-EQUITY RATIO', F15.5,/,
     *42X,'EQUITY CAPITAL',F15.5,/,40X,'BORROWED CAPITAL',F15.5)
      PRINT 52,PVAL,PV(1),EQUI,PV(2),GSUR,PV(3),ECOR,PV(4),NSUR,PV(5),
     *GTAX,PV(6),NTAX,PV(7),Z
52    FORMAT(///,63X,'PRIMARY ORE',10X,'TOTAL ORE',/,'+',62X,11('_'),
     *10X,9('_'),//,25X,'PRESENT VALUE-#1 PROJECT INVESTMENT',F14.2,5X,
```

```
     *F14.2,/,38X,'-#2 EQUITY CAPITAL',4X,F14.2,5X,F14.2,/,38X,
     *'-#3 GROSS SURPLUS',5X,F14.2,5X,F14.2,/,38X,
     *'-#4 ECONOMIC RENT',5X,F14.2,5X,F14.2,/,38X,
     *'-#5 NET SURPLUS',7X,F14.2,5X,F14.2,/,38X,
     *'-#6 GROSS ROYALTY/TAX',1X,F14.2,5X,F14.2,/,38X,
     *'-#7 NET ROYALTY/TAX',3X,F14.2,5X,F14.2,///,25X,
     *'OPTIMIZING DONE ON #',I2)
      PRINT 53
53    FORMAT(///,20X,'#1,#2,AND #4 ARE DISCOUNTED AT THE SUPPLY PRICE ',
     *'OF PRIVATE CAPITAL.',//,20X,'#3,#5,#6,AND #7 ARE DISCOUNTED AT ',
     *'THE SOCIAL OPPORTUNITY COST.')
      PRINT 54,YY,TL
54    FORMAT(//,24X,'FINAL YEAR FRACTION(PRIMARY ORE)',F14.3,/,
     *26X,'FINAL YEAR FRACTION(TOTAL ORE)',F14.3)
      DO 55  I=1,N
55    TOTINV(I)=TOTINV(I)+WORCAP(I)
      PRINT 56
56    FORMAT('1',/,52X,'NET CAPITAL INVESTMENT',/,'+',51X,22('_'),//,
     *15X,'PREPRODUCTION',1X,'PREPRODUCTION',5X,'MINING',6X,'PROCESSING'
     *,3X,'SOCIAL CAPITAL',2X,'WORKING CAP.',4X,'TOTAL',/,16X,'EXPLORATI
     *ON',3X,'DEVELOPMENT',4X,'INVESTMENT',4X,'INVESTMENT',4X,'INVESTMEN
     *T',4X,'AND SALVAGE VAL',  2X,'CAPITAL',//)
      PRINT 57,(I,EXPLOR(2,I),PREPRO(2,I),MININV(2,I),PROINV(2,I),
     *SOCINV(2,I),WORCAP(I),TOTINV(I),I=1,N)
57    FORMAT((1X,I2,12X,7(F12.2,2X))/)
      DO 58  I=1,N
58    TOTINV(I)=TOTINV(I)-WORCAP(I)
      CALL PRNROY
      CALL PRNTAX
      PRINT 59
59    FORMAT('1',//,53X,'PRESENT VALUE CALCULATIONS',/,'+',52X,26('_'),
     *//,56X,'#1 PROJECT CASH FLOW',/)
      PRINT 60
60    FORMAT(15X,'OPERATING',9X,'CAPITAL',11X,'INCOME',11X,'MINING',11X,
     *'TOTAL',8X,'WORKING CAPITAL',7X,'CASH',/,16X,'PROFIT',11X,'TAX',16
     *X,'TAX',12X,'ROYALTY',7X,'INVESTMENT', 06X,'AND SALVAGE VALUE',6X,
     *'FLOW',/)
      PRINT 61 ,(I,GROPRO(I),CAPTAX(I), TAX(I),TOTROY(I),TOTINV(I),
     *WORCAP(I),CASFLO(1,I),I=1,N)
61    FORMAT((1X,I2,07X,7F17.5)/)
      PRINT 62 ,PV(1),S
62    FORMAT(//,46X,'PRESENT VALUE IS',F14.2,//,11X,
     *'1 THE SUPPLY PRICE OF PRIVATE CAPITAL IS', F6.2,'%.')
      PRINT 63
63    FORMAT('1',//,56X,'#2 EQUITY CASH FLOW')
      PRINT 64
64    FORMAT( /,32X,'PROJECT',/,33X,'CASH',12X,'BORROWED',10X,'DEBT',
     *10X,'INTEREST',13X,'CASH',/,33X,'FLOW',12X,'CAPITAL',9X,
     *'REPAYMENT',8X,'ON DEBT',13X,'FLOW',/)
      PRINT 65 ,(I,CASFLO(1,I),BORCAP(I),PRIN(I),INTRST(I),
     *CASFLO(2,I),I=1,N)
65    FORMAT((1X,I2,23X,5F17.5)/)
      PRINT 66 ,PV(2),U,S
66    FORMAT(//,46X,'PRESENT VALUE IS',F14.2,//,11X,
     *    '1 EQUITY CASH FLOW IS THAT AFTER ADDING BORROWED CAPITAL AND
     *SUBTRACTING',//,13X,'DEBT REPAYMENT AND INTEREST.',//,11X,'2 THE B
     *ANK LENDING RATE IS',F6.2,'%.',//,11X,
     *'3 THE SUPPLY PRICE OF PRIVATE CAPITAL IS', F6.2,'%.')
      PRINT 67
67    FORMAT('1',//,61X,'#3 GROSS SURPLUS')
      PRINT 68
68    FORMAT( /,31X,'PROJECT',/,32X,'CASH',11X,'CAPITAL',12X,'INCOME',
```

```
     *10X,'MINING',12X,'CASH',/,32X,'FLOW',14X,'TAX',14X,'TAX',
     *11X,'ROYALTY',12X,'FLOW',/)
      PRINT 69 ,(I,CASFLO(1,I),CAPTAX(I),TAX(I),TOTROY(I),CASFLO(3,I),
     *I=1,N)
69    FORMAT((1X,I2,21X,5F17.5)/)
      PRINT 70 ,PV(3),V
70    FORMAT(//,46X,'PRESENT VALUE IS',F14.2,//,11X,
     *    '1 PUBLIC CASH FLOW1 ASSUMES THAT THE PROJECT WOULD NOT HAVE B
     *EEN UNDERTAKEN BY',//,13X,'A PRIVATE COMPANY SO THAT TAXES AND ROY
     *ALTIES ARE NOT A COST TO THE PROJECT.',//,11X,
     *'2 THE DISCOUNT RATE USED IS',F6.2,'%(THE SOCIAL OPPORTUNITY COST)
     *.')
      PRINT 71
71    FORMAT('1',//,60X,'#4 ECONOMIC RENT')
      PRINT 72
72    FORMAT(/ ,47X,'PROJECT',                  /,48X,'CASH',12X,'ROYALTY',
     *11X,'CASH',/,48X,'FLOW',11X,'PAYMENTS',11X,'FLOW',/)
      PRINT 73 ,(I,CASFLO(1,I),TOTROY(I),              CASFLO(4,I),I=1,N)
73    FORMAT((1X,I2,38X,3F17.5)/)
      PRINT 74 ,PV(4),S
74    FORMAT(//,46X,'PRESENT VALUE IS',F14.2,//,11X,
     *'1 ECONOMIC RENT IS THE PRESENT',
     * ' VALUE OF THE PROJECT EXCLUSIVE OF ANY ROYALTIES.',//,11X,
     *'2 THE SUPPLY PRICE OF PRIVATE CAPITAL IS', F6.2,'%.')
      PRINT 78
78    FORMAT('1',//,56X,'#5 NET SURPLUS',//,44X,
     *'GROSS',9X,'FOREGONE TAXES',
     *6X,'REMAINING',/,43X,'SURPLUS',9X,'AND ROYALTIES',7X,'SURPLUS',/)
      PRINT 79,(I,CASFLO(3,I),FORGON(I),CASFLO(5,I),I=1,N)
79    FORMAT((1X,I2,36X,3F17.5)/)
      PRINT 80,PV(5)
80    FORMAT(//,46X,'PRESENT VALUE IS',F14.2)
      PRINT 81
81    FORMAT('1',//,56X,'#6 GROSS TAXES AND ROYALTIES',//,38X,
     *'PROVINCIAL',9X,'CAPITAL',10X,'INCOME',9X,'TOTAL TAXES',/,
     *39X,'ROYALTIES',11X,'TAX',13X,'TAXES',8X,'AND ROYALTIES',/)
      PRINT 82,(I,TOTROY(I),CAPTAX(I),TAX(I),CASFLO(6,I),I=1,N)
82    FORMAT((1X,I2,31X,4F17.5)/)
      PRINT 80,PV(6)
      PRINT 84
84    FORMAT('1',//,56X,'#7 NET TAXES AND ROYALTIES',//,45X,
     *'TOTAL TAXES',6X,'FOREGONE TAXES',2X,'REMAINING TAXES',/,44X,
     * 'AND ROYALTIES',6X,'AND ROYALTIES',4X,'AND ROYALTIES',/)
      PRINT 85,(I,CASFLO(6,I),FORGON(I),CASFLO(7,I),I=1,N)
85    FORMAT((1X,I2,40X,3F17.5)/)
      PRINT 80,PV(7)
      PRINT 87
87    FORMAT('1')
      STOP
      END
```

```
C THIS SUBROUTINE DETERMINES THE INFLATIONARY DISCOUNT RATES.
C
      SUBROUTINE RATE(S,T,U,V,RI)
      REAL*8 S,T,U,V,RT,CHEK,DEXP,A,B,C,Q,  D,DABS,RI,X/1.D-15/
      DO 10 I=1,4
      GO TO (11,12,13,14),I
C
C 'A' IS THE APPROXIMATE INFLATIONARY RATE.
C
11    A=S+RI
C
C 'C' IS SET EQUAL TO THE REAL DISCOUNT RATE.
C
      C=S
      GO TO 15
12    A=T+RI
      C=T
      GO TO 15
13    A=U+RI
      C=U
      GO TO 15
14    A=V+RI
      C=V
C
C 'B' IS SET AT A VALUE ABOVE THE INFLATIONARY DISCOUNT RATE.
C
15    B=A+0.01D0
C
C 'D' IS SET AT A VALUE BELOW THE INFLATIONARY DISCOUNT RATE.
C
      D=A-0.01D0
C
C THE VALUE OF 'Q' IS FIXED BY THE RATE OF INFLATION AND THE REAL
C DISCOUNT RATE.
C
      Q=(RI*DEXP(RI)+X)/(DEXP(RI)-1.D0+X)*(C*DEXP(C)+X)/(DEXP(C)-1.D0+X)
C
C THE VALUE OF 'CHEK' WILL BE MADE ABOUT EQUAL TO 'Q' BY ADJUSTING 'A'.
C
16    CHEK=A*DEXP(A)/(DEXP(A)-1.D0)
      IF(DABS(Q-CHEK).LT.1.0D-08)GO TO 17
      IF(CHEK.LT.Q)GO TO 22
C
C SET THE UPPER LIMIT 'B' TO THE CURRENT 'A'.
C
      B=A
C
C CALCULATE A NEW VALUE FOR 'A' HALF WAY BETWEEN THE CURRENT VALUE
C AND THE LOWER LIMIT.
C
      A=(A+D)/2.D0
      GO TO 16
C
C SET THE LOWER LIMIT 'D' TO THE CURRENT 'A'.
C
22    D=A
C
C CALCULATE A NEW VALUE FOR 'A' HALF WAY BETWEEN THE CURRENT VALUE
C AND THE UPPER LIMIT.
C
      A=(A+B)/2.D0
```

```
      GO TO 16
C
C SET THE DISCOUNT RATES AT THE NEW INFLATIONARY VALUES.
C
17    GO TO (18,19,20,21),I
18    S=A
      GO TO 10
19    T=A
      GO TO 10
20    U=A
      GO TO 10
21    V=A
10    CONTINUE
      PRINT 23,S,T,U,V
23    FORMAT('1',////,40X,'DISCOUNT RATES',/,'+',39X,14('_'),//,
     *30X,'SUPPLY PRICE OF CAPITAL IN MINING',F12.9,//,
     *30X,'OPPORTUNITY COST OF CAPITAL      ',F12.9,//,
     *30X,'BANK LENDING RATE                ',F12.9,//,
     *30X,'SOCIAL DISCOUNT RATE             ',F12.9)
      RETURN
      END
```

```
C THIS SUBROUTINE CALCULATES THE SEVEN COST EQUATIONS AND THE
C TWO MINERAL RESERVE FUNCTIONS. GRAPHS OF THE EQUATIONS CAN BE
C PRINTED IF DESIRED.
C
      SUBROUTINE EQUATN(CAPCOS,L,AA,BB,H,P,PG)
      REAL*8 CAPCOS(10,8),CPACTY(20,3),A(3,7),B(3,7),R(3,7),DABS,
     *SUM(10,3,7),MINGRA,    DLOG,DSQRT,AA(7),BB(7),Z,ZZ,ZZZ,TOTMIN,SIZE,
     *VALUES(100).DEXP, Y/'CAPITAL'/, YY/'COST($)'/,YYY/'GRADE(%)'/,
     *DFLOAT,LABEL,MAXTON/0.D0/
      INTEGER LINE(100),YLABEL,POINTS(100),PERIOD/'.'/,AST/'*'/,
     *BLANK/' '/,H(7),P,Q,PG
      Q=P+1
C
C SET ALL VALUES IN THE ARRAY TO ZERO.
C
      DO 10 K=1,7
      DO 10 J=1,3
      DO 10 I=1,10
10    SUM(I,J,K)=0.D0
C
C IF MORE THAN ONE DATA CARD IS PROVIDED PROCEED TO CALCULATE THE EQUATIONS.
C
      IF(L.GT.1)GO TO 11
C
C DETERMINE THREE DATA POINTS ASSUMING A LOG-LINEAR GRADE-TONNAGE RELATION.
C
      MINGRA=CAPCOS(1,1)
      TOTMIN=CAPCOS(1,3)
      DO 12 J=1,3
      CAPCOS(J,3)=TOTMIN/(5-J)
      CAPCOS(J,2)=MINGRA*DLOG   (TOTMIN/CAPCOS(J,3))
12    CAPCOS(J,1)=CAPCOS(J,2)+MINGRA
      L=3
11    CONTINUE
C
C THE INDEPENDANT VARIABLE IS EXPRESSED IN ONE OF THREE POSSIBLE WAYS
C SO THAT LEAST SQUARES TECHNIQUES CAN BE USED TO CALCULATE THE
C TWO CONSTANTS FOR EACH EQUATION.
C THE THREE POSSIBLE EQUATIONS ARE: LINEAR; HYPERBOLIC,AND; LOG-LINEAR.
C
      DO 13 I=1,L
      CPACTY(I,1)=CAPCOS(I,Q)
      CPACTY(I,2)=-1.0D0/CAPCOS(I,Q)
13    CPACTY(I,3)=DLOG(CAPCOS(I,Q))
C
C 'P' IS THE NUMBER OF EQUATIONS, '3' IS THE NUMBER OF KINDS OF EQUATION,
C AND 'L' IS THE NUMBER OF DATA CARDS.
C
      DO 14 K=1,P
      DO 15 J=1,3
      DO 16 I=1,L
      SUM(1,J,K)=SUM(1,J,K)+CPACTY(I,J)
      SUM(2,J,K)=SUM(2,J,K)+CAPCOS(I,K)
      SUM(3,J,K)=SUM(3,J,K)+CPACTY(I,J)**2
      SUM(4,J,K)=SUM(4,J,K)+CPACTY(I,J)*CAPCOS(I,K)
16    SUM(5,J,K)=SUM(5,J,K)+CAPCOS(I,K)**2
      SUM(6,J,K)=SUM(1,J,K)**2
      SUM(7,J,K)=SUM(1,J,K)*SUM(2,J,K)
      SUM(8,J,K)=SUM(2,J,K)**2
      Z=L*SUM(5,J,K)-SUM(8,J,K)
      ZZ=L*SUM(3,J,K)-SUM(6,J,K)
```

```
      ZZZ= L*SUM(4,J,K)-SUM(7,J,K)
      B(J,K)=ZZZ/ZZ
      A(J,K)=(SUM(2,J,K)-B(J,K)*SUM(1,J,K))/L
      IF(J.EQ.2)B(J,K)=-B(J,K)
      IF(Z)17,18,17
17    IF(ZZ)20,18,20
C
C CALCULATE THE R SQUARED VALUE FOR EACH EQUATION.
C
18    R(J,K)=1.D0
      GO TO 15
20    R(J,K)=ZZZ**2/(Z*ZZ+1.0D-10)
15    CONTINUE
C
C IF THE MINERAL RESERVE FUNCTIONS ARE BEING DETERMINED  AND THE SECOND
C EQUATION IS BEING CALCULATED CHECK THE SHAPE OF THE AVERAGE GRADE
C FUNCTION. IF LINEAR THE CUTOFF GRADE FUNCTION IS ALSO LINEAR; IF
C LOG-LINEAR THE CUTOFF GRADE FUNCTION IS ALSO LOG-LINEAR, AND; IF
C HYPERBOLIC THE CUTOFF GRADE FUCTION WILL BE AS DETERMINED FROM THE DATA.
C
      IF(P.NE.2.OR.K.NE.2)GO TO 21
      IF(H(K-1)-2)22,21,23
21    CONTINUE
C
C DETERMINE WHICH EQUATION HAS THE HIGHEST R SQUARED VALUE.
C
      IF(DABS(R(1,K))-DABS(R(2,K)))24,25,25
24    IF(DABS(R(2,K))-DABS(R(3,K)))26,27,27
25    IF(DABS(R(1,K))-DABS(R(3,K)))26,28,28
C
C PLACE THE CONSTANTS IN THE ARRAY FOR RETURN TO THE MAIN PROGRAM.
C
28    AA(K)=A(1,K)
      BB(K)=B(1,K)
22    CONTINUE
C
C IDENTIFY WHICH EQUATION HAS BEEN SELECTED AS BEST EXPLAINING THE DATA.
C
      H(K)=1
C
C FOR THE SECOND EQUATION OF THE MINERAL RESERVE FUNCTIONS
C PROCEED TO THE END OF THE LOOP.
C
      IF(P.NE.2.OR.K.NE.2)GO TO 14
      AA(K)=AA(K-1)
      BB(K)=2.D0*BB(K-1)
      GO TO 14
27    AA(K)=A(2,K)
      BB(K)=B(2,K)
      H(K)=2
      GO TO 14
26    AA(K)=A(3,K)
      BB(K)=B(3,K)
23    CONTINUE
      H(K)=3
      IF(P.NE.2.OR.K.NE.2)GO TO 14
      AA(K)=AA(K-1)+BB(K-1)
      BB(K)=BB(K-1)
14    CONTINUE
C
C IF GRAPHS ARE   NOT TO BE PRINTED GO TO THE END OF THE PROGRAM.
C
```

```
      IF(PG.EQ.0)GO TO 29
      DO 30 K=1,P
      PRINT 31
31    FORMAT('1')
C
C PRINT HEADINGS.
C
      IF(P.EQ.2) GO TO 32
      GO TO (33,34,35,36,37,38,39),K
33    PRINT 40
40    FORMAT(50X,'PREPRODUCTION EXPLORATION',/,'+',49X,25('_'))
      GO TO 41
34    PRINT 42
42    FORMAT(50X,'PREPRODUCTION DEVELOPMENT',/,'+',49X,25('_'))
      GO TO 41
35    PRINT 43
43    FORMAT(50X,'MINING INVESTMENT',        /,'+',49X,17('_'))
      GO TO 41
36    PRINT 44
44    FORMAT(50X,'PROCESSING INVESTMENT',    /,'+',49X,21('_'))
      GO TO 41
37    PRINT 45
45    FORMAT(50X,'SOCIAL INVESTMENT',        /,'+',49X,17('_'))
      GO TO 41
38    PRINT 46
46    FORMAT(50X,'MINING COSTS(PER TON)',    /,'+',49X,21('_'))
      GO TO 41
39    PRINT 47
47    FORMAT(50X,'PROCESSING COSTS(PER TON)',/,'+',49X,25('_'))
      GO TO 41
32    CONTINUE
C
C DETERMINE THE TOTAL TONNAGE FOR THE DEPOSIT.
C
      IF(H(2)-2)48,49,50
48    MAXTON=-AA(2)/BB(2)
      GO TO 51
49    MAXTON=-BB(2)/AA(2)
      GO TO 51
50    MAXTON=DEXP(-AA(2)/BB(2))
51    CONTINUE
      GO TO (52,53),K
52    PRINT 54
54    FORMAT(50X,'AVERAGE ORE GRADE',/,'+',49X,17('_'))
      GO TO 41
53    PRINT 55
55    FORMAT(50X,'CUTOFF  ORE GRADE',/,'+',49X,17('_'))
41    CONTINUE
C
C PRINT THE EQUATION FOR EACH GRAPH.
C
      IF(H(K)-2)56,57,58
56    PRINT59,AA(K),BB(K)
59    FORMAT(/ ,43X,'Y=',F15.5, '+(',F16.12,')X',/)
      GO TO 60
57    PRINT61,AA(K),BB(K)
61    FORMAT(/ ,43X,'Y=',F15.5, '+(',F15.5,')/X',/)
      GO TO 60
58    PRINT62,AA(K),BB(K)
62    FORMAT(/ ,43X,'Y=',F15.5, '+(',F15.5,')LN(X)',/)
60    CONTINUE
C
```

```
C DETERMINE A SERIES OF POINTS FOR PLOTTING ON A GRAPH.
C
      DO 63 I=1,100
      SIZE=DFLOAT(I)*10.D0**4
      IF(P.EQ.2)SIZE=DFLOAT(I)*10.D0**5
      IF(H(K)-2)64,65,66
64    VALUES(I)=AA(K)+BB(K)*SIZE
      GO TO 67
65    VALUES(I)=AA(K)+BB(K)/SIZE
      GO TO 67
66    VALUES(I)=AA(K)+BB(K)*DLOG(SIZE)
67    CONTINUE
C
C DETERMINE INTEGER VALUES FOR EACH OF THE POINTS ACCORDING TO THE AXIS SIZE.
C
      IF(P.EQ.2)GO TO 68
      IF(K.GT.5)GO TO 69
      POINTS(I)=(VALUES(I)/10.D0**5)/2.D0+0.5D0
      GO TO 63
69    POINTS(I)=VALUES(I)/2.D0+0.5D0
      GO TO 63
68    POINTS(I)=VALUES(I) *1000.D0/2.D0+0.5D0
63    CONTINUE
C
C DETERMINE AN INTEGER VALUE FOR THE DEPOSIT SIZE.
C
      LIMIT=MAXTON/100000.D0+0.5D0
C
C PRINT THE GRAPH IN 50 STEPS BEGINNING AT THE TOP.
C
      DO 70 J=1,10
      DO 70 L=1,5
      I=51-(5*(J-1)+L)
C
C CLEAR THE LINE TO BE PRINTED.
C
      DO 71 M=1,100
71    LINE(M)=BLANK
C
C WHEN THE INTEGER VALUE IN 'POINTS' EQUALS 'I' PLACE '*' IN THE LINE.
C
      DO 72 M=1,100
72    IF(POINTS(M).EQ.I)LINE(M)=AST
      IF(P.EQ.2.AND.I.LE.25)LINE(LIMIT)=AST
C
C PRINT THE LABEL ON THE VERTICAL AXIS AT THE APPROPRIATE TIME.
C
      IF(L.EQ.1)GO TO 73
C
C PRINT A LINE OF THE GRAPH.
C
      IF(I.EQ.26.AND.P.NE.2.AND.K.LE.5)GO TO 74
      PRINT 75 ,LINE
75    FORMAT(19X,'.',100A1)
      GO TO 70
74    PRINT 76,LINE
76    FORMAT(6X,'MILLIONS$',4X,'.',100A1)
      GO TO 70
73    CONTINUE
      IF(P.EQ.2)GO TO 77
      IF(K.GT.5)GO TO 78
      LABEL=BLANK
```

```
      IF(I.EQ.25)LABEL=Y
      YLABEL=2*I/10
      GO TO 79
78    LABEL=BLANK
      IF(I.EQ.25)LABEL=YY
      YLABEL=2*I
      GO TO 79
77    LABEL=BLANK
      IF(I.EQ.25)LABEL=YYY
      YLABEL=2*I/10
79    PRINT80,LABEL,YLABEL,LINE
80    FORMAT(4X,A11,I3,' .',100A1)
70    CONTINUE
C
C PRINT THE HORIZONTAL AXIS.
C
      DO 81 I=1,100
81    LINE(I)=PERIOD
      PRINT82,LINE,(I,I=1,10)
82    FORMAT(17X,'0 .',100A1,//,19X,'0',10(7X,I3),//)
C
C PRINT THE LABEL FOR THE HORIZONTAL AXIS.
C
      IF(P.EQ.2)GO TO 84
      PRINT 83
83    FORMAT(50X,'ANNUAL CAPACITY (TONS 10**5)')
      GO TO 30
84    PRINT 85
85    FORMAT(50X,'MINERAL RESERVES (TONS 10**6)')
30    CONTINUE
      PRINT 31
29    CONTINUE
      RETURN
      END
```

```
C THIS SUBROUTINE CALCULATES THE ANNUAL GROSS REVENUE AND PRINTS THE
C PRODUCTION DETAILS.
C
      SUBROUTINE ANNREV
      REAL *8 METAL(50),SIZZ(50),DABS,SIZE,VALUE,TL,YTONS,
     *REVENU(50),GRADE(50),CCGRAD(50),TONS,RCV(50),DLOG,
     *PTONS,PCGRAD,PAVGRA,PMETAL,TTONS,AVGRAD,TMETAL,COGRAD,TAVGRA,
     *TOPCOS,XTONS,    XAVGRA,XYEARS,DEXP,GRAD(02),A(7),B(7),
     *INFLA2(50),INFLA3(50),R1/-0.00125D0/,R2/0.97D0/
      INTEGER C,D,N,LIFE,HH(7),HG
      COMMON /B1/INFLA2/B6/INFLA3,SIZZ,REVENU,A,B,VALUE,TOPCOS
     */B8/HH,LIFE/B9/IY/B12/HG,IOP/B0/C,D,N
      DO 10 I=1,D
      METAL (I)=0.D0
      GRADE (I)=0.D0
      REVENU(I)=0.D0
10    CCGRAD(I)=0.D0
      TONS=0.D0
C
C IF THE DEPOSIT IS TO BE HIGH-GRADED BYPASS THE SECTION WHICH ASSUMES
C PRODUCTION IS AT THE AVERAGE GRADE OF THE DEPOSIT.
C
      IF(HG.EQ.1)GO TO 18
C
C DETERMINE THE TONS OF PRIMARY ORE.
C
      DO 11 I=C,N
11    TONS=TONS+SIZZ(I)
C
C DETERMINE THE AVERAGE AND CUTOFF GRADES FOR THE ORE.
C
      DO 12  J=1,2
      IF(HH(J)-2)13,14,15
13    GRAD(J)=A(J)+B(J)*TONS
      GO TO 12
14    GRAD(J)=A(J)+B(J)/TONS
      GO TO 12
15    GRAD(J)=A(J)+B(J)*DLOG(TONS)
12    CONTINUE
C
C SET ANNUALLY FOR THE PRODUCTIVE LIFE OF THE PROJECT THE PRIMARY AND
C SECONDARY CUTOFF GRADES, THE PRIMARY METAL PRODUCTION,
C AND THE TOTAL REVENUE.
C
      DO 16 I=C,N
      GRADE(I)=GRAD(1)
      CCGRAD(I)=GRAD(2)
      RCV(I)=R1/GRADE(I)+(R2-GRADE(I))*DEXP(GRADE(I))
      METAL(I)=SIZZ(I)*RCV(I)*GRADE(I)*2000.D0
16    REVENU (I)=METAL(I)*VALUE*INFLA3(I)
      AVGRAD=GRAD(1)
      GO TO 17
18    CONTINUE
C
BEGIN HIGH- GRADING THE ORE.
C
      DO 19 I=C,N
      IF(I.EQ.C)GO TO 20
C
C DETERMINE THE AMOUNT OF ORE PRODUCED IN THE PREVIOUS YEARS.
C
```

```
      PTONS=PTONS+SIZZ(I-1)
C
C DETERMINE THE AVERAGE GRADE OF THAT ORE.
C
      IF(HH(1)-2)21,22,23
21    PAVGRA=A(1)+B(1)*PTONS
      GO TO 24
22    PAVGRA=A(1)+B(1)/PTONS
      GO TO 24
23    PAVGRA=A(1)+B(1)*DLOG(PTONS)
24    CONTINUE
C
C DETERMINE THE CUTOFF GRADE OF THAT ORE.
C
      IF(HH(2)-2)25,26,27
25    PCGRAD=A(2)+B(2)*PTONS
      GO TO 28
26    PCGRAD=A(2)+B(2)/PTONS
      GO TO 28
27    PCGRAD=A(2)+B(2)*DLOG(PTONS)
C
C CALCULATE THE PREVIOUS METAL PRODUCTION.
C
28    PMETAL=PTONS*PAVGRA
      GO TO 29
20    PTONS=0.D0
      PCGRAD=0.D0
      PAVGRA=0.D0
      PMETAL=0.D0
C
C CALCULATE TOTAL ORE PRODUCTION TO DATE.
C
29    TONS=TONS+SIZZ(I)
C
C CALCULATE THE CUTOFF GRADE FOR THE PRODUCTION TO DATE.
C
      IF(HH(2)-2)30,31,32
30    CCGRAD(I)=A(2)+B(2)*TONS
      GO TO 33
31    CCGRAD(I)=A(2)+B(2)/TONS
      GO TO 33
32    CCGRAD(I)=A(2)+B(2)*DLOG(TONS)
33    CONTINUE
C
C CALCULATE THE AVERAGE GRADE FOR THE PRODUCTION TO DATE.
C
      IF(HH(1)-2)34,35,36
34    AVGRAD=A(1)+B(1)*TONS
      GO TO 37
35    AVGRAD=A(1)+B(1)/TONS
      GO TO 37
36    AVGRAD=A(1)+B(1)*DLOG(TONS)
C
C CALCULATE TOTAL METAL PRODUCTION TO DATE.
C
37    TMETAL=TONS*AVGRAD
C
C CALCULATE THE AVERAGE GRADE OF THIS YEARS ORE PRODUCTION.
C
      GRADE(I)=(TMETAL-PMETAL)/SIZZ(I)
      RCV(I)=R1/GRADE(I)+(R2-GRADE(I))*DEXP(GRADE(I))
C
```

```
C CALCULATE THIS YEARS METAL PRODUCTION.
C
      METAL(I)=(TMETAL-PMETAL)*RCV(I)*2000.D0
C
C CALCULATE THIS YEARS GROSS REVENUE.
C
19    REVENU(I)=METAL(I)*VALUE*INFLA3(I)
17    CONTINUE
      IY=0
      TTONS=TONS
C
C IF THE FINAL PROJECT HAS NOT BEEN DETERMINED GO TO THE END OF THE PROGRAM.
C
      IF(IOP .NE.1)GO TO 38
C
C THIS IS THE APPROXIMATE RECOVERY RATE FOR THE SECONDARY ORE.
C
      RCV(N)=R1/CCGRAD(N)+(R2-CCGRAD(N))*DEXP(CCGRAD(N))
39    CONTINUE
      RCV(N+1)=RCV(N)
C
C DETERMINE THE CUTOFF GRADE FOR THE SECONDARY ORE.
C
      COGRAD=TOPCOS/(VALUE*RCV(N)*2000.0D0)*INFLA2(N)/INFLA3(N)
C
C IF FOR SOME REASON THE FINAL CUTOFF GRADE IS GREATER THAN THE PRIMARY
C ORE CUTOFF GRADE GO TO THE END OF THE PROGRAM.
C
      IF(COGRAD.GE.CCGRAD(N))GO TO 38
C
C CALCULATE THE TOTAL ORE AS DETERMINED BY THE FINAL CUTOFF GRADE.
C
      IF(HH(2)-2)40,41,42
40    TTONS=(COGRAD-A(2))/B(2)
      GO TO 43
41    TTONS=B(2)/(COGRAD-A(2))
      GO TO 43
42    TTONS=DEXP((COGRAD-A(2))/B(2))
43    CONTINUE
C
C DETERMINE THE AVERAGE GRADE OF THAT ORE.
C
      IF(HH(1)-2)44,45,46
44    TAVGRA=A(1)+B(1)*TTONS
      GO TO 47
45    TAVGRA=A(1)+B(1)/TTONS
      GO TO 47
46    TAVGRA=A(1)+B(1)*DLOG(TTONS)
47    CONTINUE
C
C DETERMINE THE AMOUNT OF SECONDARY ORE.
C
      XTONS= TTONS-TONS
      IF(XTONS.LE.0.D0 )GO TO 38
C
C DETERMINE THE AVERAGE GRADE OF THE SECONDARY ORE.
C
      XAVGRA= (TTONS*TAVGRA-TONS*AVGRAD)/XTONS
      RCV(N)=R1/XAVGRA+(R2-XAVGRA)*DEXP(XAVGRA)
C
C IF THE RECOVERY RATE NOW DIFFERS SIGNIFICANTLY FROM THE RATE PREVIOUSLY
C USED ADJUST THE RATE AND RECALCULATE THE AMOUNT OF SECONDARY ORE.
```

```
C
      IF(DABS(RCV(N)-RCV(N+1)).LE.0.001D0)GO TO 48
      IF(RCV(N)-RCV(N+1))49,48,50
49    RCV(N)=RCV(N+1)-(RCV(N+1)-RCV(N))/2.D0
      GO TO 39
50    RCV(N)=RCV(N+1)+(RCV(N)-RCV(N+1))/2.D0
      GO TO 39
48    CONTINUE
C
C DISTRIBUTE THE SECONDARY ORE OVER AS MANY ADDITIONAL YEARS AS NEEDED.
C
      YTONS=0.D0
      IF(SIZZ(N).EQ.SIZZ(C))GO TO 51
C
C DETERMINE THE AMOUNT OF SECONDARY ORY TO INCLUDE WITH THE FINAL
C YEARS PRODUCTION OF PRIMARY ORE.
C
      YTONS=SIZZ(C)-SIZZ(N)
      IF(XTONS.LT.YTONS)YTONS=XTONS
      GRADE(N)=(YTONS*XAVGRA+SIZZ(N)*AVGRAD)/(SIZZ(N)+YTONS)
      SIZZ(N)=SIZZ(N)+YTONS
52    RCV(N)=R1/GRADE(N)+(R2-GRADE(N))*DEXP(GRADE(N))
      CCGRAD(N)=COGRAD
      METAL(N)=SIZZ(N)*RCV(N)*GRADE(N)*2000.D0
      REVENU(N)=VALUE*METAL(N)*INFLA3(N)
51    XTONS=XTONS-YTONS
      IF(XTONS.LE.0.D0)GO TO 38
C
C IF MOPE SECONDARY ORE REMAINS EXTEND THE LIFE OF THE PROJECT.
C
      N=N+1
C
C RECORD THE NUMBER OF YEARS OF SECONDARY ORE PRODUCTION.
C
      IY=IY+1
      IF(XTONS-SIZZ(C))53,53,54
53    SIZZ(N)=XTONS
      XTONS=0.D0
      GRADE(N)=XAVGRA
      GO TO 52
54    YTONS=       SIZZ(C)
      SIZZ(N)=SIZZ(C)
      GRADE(N)=XAVGRA
      GO TO 52
38    CONTINUE
      RETURN
C
C PRINT PRODUCTION DETAILS FOR THE OPTIMUM PROJECT.
C
      ENTRY PRNPRO
      PRINT 55
55    FORMAT(20X,'TONS' ,12X,'AVERAGE',08X,'CUTOFF',6X,'PRIMARY METAL',
     *04X,'CONCENTRATE',/,19X,'OF ORE',12X,'GRADE',09X,'GRADE',7X,'IN CO
     *NCEN(LBS)',    5X,'VALUE($)',//)
      DO56 I=C,N
      GRADE(I)=GRADE(I)*100.D0
56    CCGRAD(I)=CCGRAD(I)*100.D0
      PRINT57,(I,SIZZ(I),GRADE(I),CCGRAD(I),METAL(I), REVENU(I),I=1,N)
57    FORMAT((1X,I2,08X,F16.5,2(F16.5,'%') ,2F16.5)/)
      PRINT 58,TONS,TTONS
58    FORMAT(////,38X,'PRIMARY ORE PRODUCTION',F12.1,'TONS',//,40X,
     *'TOTAL ORE PRODUCTION',F12.1,'TONS')
```

```
RETURN
END
```

```
C THIS SUBROUTINE DETERMINES  THE ANNUAL INTEREST PAYMENTS AND ANNUAL
C AMOUNT TO BE PAID ON THE PRINCIPAL.
C
      SUBROUTINE DEBT
      REAL*6 S,DETREP,INTRST(50),CAPUB(50),PRIN(50)
      INTEGER C,D,U,V
      COMMON /B4/INTRST,PRIN,S/B11/CAPUB/B9/IY/B0/C,D,N
C
C DETERMINE THE REPAYMENT PERIOD.
C
      U=N-IY-C+1
      IF(U.GE.20)V=20
      IF(U.GE.15.AND.U.LT.20)V=15
      IF(U.GE.10.AND.U.LT.15)V=10
      IF(U.LT.10)V=U
      I=C
C
C DETERMINE THE ANNUAL EQUAL PAYMENTS TO PROVIDE FOR THE
C INTEREST AND PRINCIPAL.
C
      DETREP=CAPUB(I-1)*(S*(1.D0+S)**V+1.D-15)/((1.D0+S)**V-1.D0+1.D-15)
      L=C+V-1
C
C SEPARATE THE INTEREST AND PRINCIPAL AND PLACE THEM IN ARRAYS
C FOR USE IN THE INCOME TAX SUBROUTINE.
C
      DO 02 I=C,L
      INTRST(I)=S*CAPUB(I-1)
      PRIN(I)=DETREP-INTRST(I)
02    CAPUB(I)=CAPUB(I-1)-PRIN(I)
      LL=L+1
      DO 03 I=LL,N
      INTRST(I)=0.D0
      PRIN(I)=0.D0
03    CAPUB(I)=0.D0
      RETURN
      END
```

```
C THIS SUBROUTINE CALCULATES THE PRESENT VALUE OF THE SEVEN REVENUE FLOWS.
C
      SUBROUTINE PRVAL
      REAL*8 CASFLO(8,50),PV(8),DEXP,T,FY,AI,DFLOAT,S,U,Z/1.D-15/
      INTEGER C,D
      COMMON /B3/FY/B7/CASFLO,PV,S,U,IC/B0/C,D,N
      DO 20 K=1,IC
      PV(K)=0.D0
C
C USE THE SUPPLY PRICE OF CAPITAL AS A DISCOUNT RATE.
C
      T=S
C
C WHERE APPROPRIATE USE THE SOCIAL OPPORTUNITY COST AS A DISCOUNT RATE.
C
      IF (K.EQ.3.OR.K.GE.5)T=U
      DO 10 I=1,N
      AI=DFLOAT(I)
      IF(I.LT.N)GO TO 10
C
C IN THE FINAL YEAR DISCOUNT ONLY FOR THE TIME PRODUCTION OCCURS.
C
      AI=DFLOAT(N-1)+FY
10    PV(K)=PV(K)+CASFLO(K,I)*(DEXP(T)-1.D0+Z)/(T*DEXP(T*AI)+Z)
20    CONTINUE
      RETURN
      END
```

```
C THIS SUBROUTINE CALCULATES MANITOBA ROYALTY ASSESSMENTS AS OF 1969.
C
      SUBROUTINE ROYALT
      REAL*8 RI,     SUM,PROFIT(50),CMPROC(50),R,S,DEPREC(50),PROF3,
     *GROPRO(50),DEPCAL,MINALO,MAXALO,MINPRO(50),TOTUB(50),PROF1,PROF2,
     *TOTINV(50),ROY2(50),   ROY3(50),   PALLOW(50),ROYPRO(50),TOTROY(50),
     *EXPLOR(2,50),PPEPRO(2,50),MININV(2,50),PROINV(2,50),SOCINV(2,50),
     *TAX(50),CAPTAX(50),WORCAP(50),ROY1(50)
      INTEGER C,D,IC
      COMMON GROPRO,MININV,PROINV,EXPLOR,SOCINV,PREPRO,TOTROY,TAX,
     *CAPTAX,WORCAP /B2/S,RI/B0/C,D,N/B9/IY//IQ
      SUM=0.D0
      DO 9000 I=1,D
      DEPREC(I)=0.D0
      PALLOW(I)=0.D0
      ROYPRO(I)=0.D0
      TOTROY(I)=0.D0
      PROFIT(I)=0.D0
      MINPRO(I)=0.D0
      TOTINV(I)=0.D0
      TOTUB(I)=0.D0
      ROY1(I)=0.D0
      ROY2(I)=0.D0
      ROY3(I)=0.D0
C
C DETERMINE THE TOTAL INVESTMENT IN THE PROJECT.
C
9000  SUM=SUM+EXPLOR(1,I)+PREPRO(1,I)+MININV(1,I)+PROINV(1,I)+
     *SOCINV(1,I)
C
C DETERMINE THE TOTAL PROCESSING INVESTMENT.
C
      I=1
      CMPROC(I)=PROINV(1,I)
      DO 9001 I=2,D
9001  CMPROC(I)=CMPROC(I-1)+PROINV(1,I)
      IC=D+3
C
C DETERMINE THE DEPRECIATION RATE TO USE.
C
      ID=N-D-IY
      R=1.D0/DFLOAT(ID)
      IF(R.LT.0.1D0)R=0.1D0
      IF(R.GT.0.3D0)R=0.3D0
      R=0.1D0
      DO 9500 I=C,N
C
C DEDUCT ONGOING EXPLORATION IF ANY.
C
      PROFIT(I)=GROPRO(I)-EXPLOR(2,I)
      IF(PROFIT(I).LT.0.D0)PROFIT(I)=0.D0
C
C RECORD THE AMOUNT AND KIND OF ANY ONGOING INVESTMENT.
C
      TOTINV(I)=MININV(2,I)+PROINV(2,I)+SOCINV(2,I)
      IF(I.EQ.C)TOTINV(I)=TOTINV(I)+SUM
      TOTUB(I)=TOTINV(I)
      CMPROC(I)=CMPROC(I-1)+PROINV(2,I)
      DEPREC(I)=0.D0
C
C DEDUCT DEPRECIATION FROM EACH YEARS UNDEPRECIATED BALANCE.
```

```
C THE METHOD IS STRAIGHT LINE.
C
      DO 9002 J=C,I
      IF(TOTUB(J).LE.0.D0)GO TO 9002
      DEPCAL=R*TOTINV(J)
      IF((DEPREC(I)+DEPCAL).LE.PROFIT(I)) GO TO 9004
      DEPCAL=PROFIT(I)-DEPREC(I)
9004  IF(DEPCAL.GT.TOTUB(J))DEPCAL=TOTUB(J)
      DEPREC(I)=DEPREC(I)+DEPCAL
      TOTUB(J)=TOTUB(J)-DEPCAL
      IF(DEPREC(I).GE.PROFIT(I))GO TO 9006
9002  CONTINUE
C
C DETERMINE THE PROFIT AFTER DEDUCTING THE DEPRECIATION ALLOWANCE.
C
9006  MINPRO(I)=PROFIT(I)-DEPREC(I)
C
C DETERMINE THE PROCESSING ALLOWANCE.
C
      PALLOW(I)=0.08D0*CMPROC(I)
      MINALO=0.15D0*MINPRO(I)
      MAXALO=0.65D0*MINPRO(I)
      IF(PALLOW(I).GT.MAXALO)PALLOW(I)=MAXALO
      IF(PALLOW(I).LT.MINALO)PALLOW(I)=MINALO
C
C DETERMINE THE MINING PROFIT.
C
      ROYPRO(I)=MINPRO(I)-PALLOW(I)
C
C DIVIDE THE MINING PROFIT INTO THREE AMOUNTS FOR PURPOSES OF THE
C ROYALTY CALCULATION.
C
      PROF1=0.D0
      PROF2=0.D0
      PROF3=0.D0
      IF(ROYPRO(I).LE.1.0D+06)GO TO 9007
      IF(ROYPRO(I).GT.1.0D+06.AND.ROYPRO(I).LE.5.0D+06)GO TO 9008
      PROF3=ROYPRO(I)-5.0D+06
9008  PROF2=ROYPRO(I)-1.0D+06-PROF3
9007  PROF1=ROYPRO(I)-PROF2-PROF3
C
C IF THE THREE YEAR PERIOD OF REDUCED ROYALTY RATES IS PAST
C CALCULATE THE ROYALTY AT FULL RATES.
C
      IF(I.GT.IC)GO TO 9009
      ROY1(I)=PROF1*0.030D0
      ROY2(I)=PROF2*0.045D0
      ROY3(I)=PROF3*0.055D0
      GO TO 9010
9009  ROY1(I)=PROF1*0.060D0
      ROY2(I)=PROF2*0.090D0
      ROY3(I)=PROF3*0.110D0
C
C THE TOTAL ROYALTY IS THE SUM OF THE ROYALTIES DETERMINED AT THE
C THREE RATES.
C
9010  TOTROY(I)=ROY1(I)+ROY2(I)+ROY3(I)
9500  CONTINUE
      RETURN
C
C PRINT THE DETAILS OF THE ROYALTY CALCULATION FOR THE OPTIMUM PROJECT.
C
```

```
      ENTRY PRNROY
      PRINT9030
9030  FORMAT('1',51X,'ROYALTY CALCULATION (1969)',/,'+',51X,26('_'),/,
     *'-',9X,'PROFIT',10X,'ANNUAL', 8X,'PROCESSING',7X,'ROYALTY',08X,
     *'ROYALTY',11X,'ROYALTY',9X,'ROYALTY',09X,'TOTAL',/,
     *6X, 'AFTER EXPLOR',4X,'DEPRECIATION',6X,'ALLOWANCE',08X,'PROFIT',
     *8X,'(LOW RATE)',8X,'(MED RATE)',6X,'(HI RATE)',7X,'ROYALTY',//)
      PRINT9031,(I,PROFIT(I),DEPREC(I),PALLOW(I),ROYPRO(I),ROY1(I),
     *ROY2(I),ROY3(I),TOTROY(I),I=1,N)
9031  FORMAT((1X,I2,1X,8F16.5)/)
      PRINT9032
9032  FORMAT('1',//,34X,'YEARLY',6X,'CUMULATIVE',11X,'ANNUAL',10X,
     *'FINAL', /,31X,'TOTAL INVEST',2X,'PROCESS INVEST',5X,
     *'DEPRECIATION',2X,'UNDEPREC BALANCE',//)
      PRINT9033,(I,TOTINV(I), CMPROC(I),DEPREC(I),TOTUB(I),I=1,N)
9033  FORMAT((1X,I2,25X,4F16.5)/)
      RETURN
      END
```

```
C THIS SUBROUTINE CALCULATES TOTAL INCOME TAX ASSESSMENTS AS OF 1969.
C
      SUBROUTINE INCTAX
      REAL*8 GROPRO(50),INTRST(50),WORCAP(50),CAPUB (50),BORCAP(50),
     *EXPLOR(2,50),PREPRO(2,50),MININV(2,50),PROINV(2,50),SOCINV(2,50),
     *TTPROF,S,  FIXUB(50),TAPROF(50),TAX(50),PRIN(50),SM,SC,PREUB(50),
     *DER,NCCA(50),AD,AE,SV,DEPLAL(50),FIXINV(50),PROF1,CAPTAX(50),TL,
     *DABS,PREALO(50),TAXCAR(50),INFLA2(50),TGROPR(50),XMPROF(50),TK,
     *FIXCAP(50),PRECAP(50),TOTROY(50),CMXPLR(50),XPLCAP(50),XPLDED(50)
      INTEGER C,D
      COMMON GROPRO,MININV,PROINV,EXPLOR,SOCINV,PREPRO,TOTROY,TAX,
     *CAPTAX,WORCAP /B1/INFLA2/B3/TL/B4/INTRST,PRIN,S
     */B5/BORCAP,DER,SM,SC/B9/IY/B11/CAPUB/B0/C,D,N//IQ
C
C SET THE FINAL YEAR OF THE TAX FREE PERIOD.
C
      IC=D+3
      AD=0.D0
      AE=0.D0
C
C FOR SMALL PROJECTS EXPLORATION AND DEVELOPMENT IS RECOVERED
C IMMEDIATELY FROM OTHER INCOME. 'IQ' WILL EQUAL '1' IF THIS IS THE CASE.
C
      IF(IQ.EQ.0)GO TO 1090
      AD=1.0D0
      AE=1.0D0
1090  CONTINUE
      DO 1100 I=1,D
      CAPTAX(I)=0.D0
      TAX(I)=0.D0
      TAPROF(I)=0.D0
      PREALO(I)=0.D0
      TGROPR(I)=0.D0
      XPLDED(I)=0.D0
      DEPLAL(I)=0.D0
      NCCA  (I)=0.D0
      PRIN(I)=0.D0
      INTRST(I)=0.D0
      TAXCAR(I)=0.D0
      XMPROF(I)=0.D0
      FIXINV(I)=MININV(1,I)+PROINV(1,I)+SOCINV(1,I)
C
C DETERMINE THE AMOUNT OF BORROWED CAPITAL FOR EACH YEAR OF THE
C PREPRODUCTION PERIOD.
C
1100  BORCAP(I)=(FIXINV(I)+PREPRO(1,I)+EXPLOR(1,I)+WORCAP(I))*DER
      I=1
C
C ADD INTEREST TO THE CAPITAL BORROWED.
C
      CAPUB (I)=BORCAP(I)*(1.D0+S)
C
C THE INTEREST IS CAPITALIZED AND WILL LATER REDUCE THE TAXABLE INCOME
C WHEN A CAPITAL COST ALLOWANCE IS CLAIMED.
C
      FIXCAP(I)=FIXINV(I)*DER*(1.D0+S)
      PRECAP(I)=PREPRO(1,I)*DER*(1.D0+S)
      XPLCAP(I)=EXPLOR(1,I)*DER*(1.D0+S)
C
C FOR PURPOSES OF THE CAPITAL COST ALLOWANCE THE ASSET POOL IS
C INCREASED BY THE AMOUNT OF THE INTEREST.
```

```
C
      FIXUB (I)=FIXINV(I)*(1.D0+DER*S)
      PREUB(I)=PREPRO(1,I)*(1.D0+DER*S)
C
C THE NET COST TO THE FIRM FOR ANY CATEGORY OF ASSET IS
C THE GROSS COST LESS THE TAX SAVING AT THE TIME OF INVESTMENT.
C
      PREPRO(2,I)=PREPRO(2,I)-PREUB(I)*AD*0.51D0
C
C REDUCE THE UNDEPRECIATED BALANCE BY THE AMOUNT OF THE CAPITAL COST
C ALLOWANCE CLAIM.
C
      PREUB(I)=PREUB(I)*(1.D0-AD)
      CMXPLR(I)=EXPLOR(1,I)*(1.D0+DER*S)
      EXPLOR(2,I)=EXPLOR(2,I)-CMXPLR(I)*AE*0.51D0
      CMXPLR(I)=CMXPLR(I)*(1.D0-AE)
      DO 1000 I=2,D
C
C THE TOTAL BORROWED CAPITAL IS THE AMOUNT OWING FROM THE PREVIOUS YEAR
C PLUS THE  AMOUNT BORROWED THIS YEAR PLUS THE CURRENT INTEREST ON THE TOTAL.
C
      CAPUB (I)=(BORCAP(I)+CAPUB (I-1))*(1.D0+S)
      FIXCAP(I)=FIXINV(I)*DER*(1.D0+S)+FIXCAP(I-1)*(1.D0+S)
      PRECAP(I)=PREPRO(1,I)*DER*(1.D0+S)+PRECAP(I-1)*(1.D0+S)
      XPLCAP(I)=EXPLOR(1,I)*DER*(1.D0+S)+XPLCAP(I-1)*(1.D0+S)
C
C THE UNDEPRECIATED BALANCE IS THE SUM OF CURRENT INVESTMENT PLUS
C INTEREST ON THE AMOUNT BORROWED PLUS INTEREST ON THE CAPITAL PREVIOUSLY
C BORROWED PLUS THE PREVIOUS UNDEPRECIATED BALANCE.
C
      FIXUB (I)=FIXINV(I)*(1.D0+DER*S)+FIXCAP(I-1)*S+FIXUB (I-1)
      PREUB(I)=PREPRO(1,I)*(1.D0+DER*S)   +PRECAP(I-1)*S+PREUB(I-1)
C
C THE NET COST IS REDUCED BY THE TAX SAVING.
C
      PREPRO(2,I)=PREPRO(2,I)-PREUB(I)*AD*0.51D0
      PREUB(I)=PREUB(I)*(1.D0-AD)
      CMXPLR(I)=EXPLOR(1,I)*(1.D0+DER*S)  +XPLCAP(I-1)*S+CMXPLR(I-1)
      EXPLOR(2,I)=EXPLOR(2,I)-CMXPLR(I)*AE*0.51D0
1000  CMXPLR(I)=CMXPLR(I)*(1.D0-AE)
C
C DETERMINE THE ANNUAL INTEREST PAYMENTS AND THE AMOUNT TO BE PAID
C ON THE PRINCIPAL.
C
      CALL DEBT
C
C IN THE FINAL YEAR OF PRODUCTION THIS WILL BE A FRACTION THAT
C WILL LIMIT THE AMOUNT OF THE DEPRECIATION CLAIM.
C
      TK=1.D0
      DO 1001 I=C,N
      IF(I.EQ.N)TK=TL
      CAPTAX(I)=0.D0
      NCCA(I)=0.D0
      XPLDED(I)=0.D0
      DEPLAL(I)=0.D0
      TAXCAR(I)=0.D0
      XMPROF(I)=0.D0
      PREALO(I)=0.D0
C
C ONGOING INVESTMENT IS THE SUM OF THE INVESTMENT IN MINING,
C PROCESSING, AND SERVICE ASSETS.
```

```
      FIXINV(I)=MININV(2,I)+PROINV(2,I)+SOCINV(2,I)
      FIXUB(I)=FIXUB(I-1)+FIXINV(I)
      PREUB(I)=PREUB(I-1)+PREPRO(2,I)
      CMXPLR(I)=CMXPLR(I-1)+EXPLOR(2,I)
      TGROPR(I)=GROPRO(I)
      IF(I.NE.N)GO TO 1060
C
C IN THE FINAL YEAR OF PRODUCTION ASSET SALVAGE VALUE CAN REDUCE THE
C UNDEPRECIATED BALANCE OF THE FIXED INVESTMENT. ANY REMAINING VALUE
C IS ADDED TO INCOME.
C
      SV=SM+SC
      IF(SV-FIXUB(I))1061,1061,1062
1061  FIXUB(N)=FIXUB(N)-SV
      GO TO 1060
1062  SV=SV-FIXUB(N)
      FIXUB(N)=0.D0
      TGROPR(N)=TGROPR(N)+SV
1060  CONTINUE
      PROF1=TGROPR(I)
      IF(TGROPR(I).LT.0.D0)TGROPR(I)=0.D0
C
C INCOME IS REDUCED BY INTEREST AND ROYALTY PAYMENTS.IF IT IS NEGATIVE
C IT IS CARRIED FORWARD AS A TAXABLE LOSS.
C
      PROF1=PROF1-INTRST(I)-TOTROY(I)
C
C IF INCOME IS NEGATIVE OR THE TAX EXEMPT PERIOD IS STILL IN EFFECT
C DO NOT CLAIM ANY CAPITAL COST ALLOWANCE.
C
      IF(PROF1.LE.0.D0.OR.I.LE.IC)GO TO 1002
C
C INCOME IS REDUCED BY THE FULL AMOUNT OF EXPLORATION COSTS.
C
      IF(PROF1.GT.CMXPLR(I))GO TO 1126
      XPLDED(I)=PROF1
      CMXPLR(I)=CMXPLR(I)-XPLDED(I)
      PROF1=0.D0
      GO TO 1002
1126  XPLDED(I)=CMXPLR(I)
      CMXPLR(I)=0.D0
      PROF1=PROF1-XPLDED(I)
C
C INCOME IS REDUCED BY THE FULL AMOUNT OF PREPRODUCTION DEVELOPMENT COSTS.
C
      IF(PROF1.GT.PREUB(I))GO TO 1127
      PREALO(I)=PROF1
      PREUB(I)=PREUB(I)-PREALO(I)
      PROF1=0.D0
      GO TO 1002
1127  PREALO(I)=PREUB(I)
      PREUB(I)=0.D0
      PROF1=PROF1-PREALO(I)
C
C FIXED INVESTMENT IS RECOVERED AT THIRTY PERCENT OF THE
C UNDEPRECIATED BALANCE.
C
      NCCA(I)=0.3D0*FIXUB(I)*TK
      IF(PROF1.GT.NCCA(I))GO TO 1125
      NCCA(I)=PROF1
      FIXUB(I)=FIXUB(I)-NCCA(I)
```

```
      PROF1=0.D0
      GO TO 1002
 125  PROF1=PROF1-NCCA(I)
      FIXUB(I)=FIXUB(I-1)-NCCA(I)
      DEPLAL(I)=PROF1/3.D0
      PROF1=PROF1-DEPLAL(I)
 002  TAPROF(I)=PROF1
  A TAXABLE LOSS CAN BE CARRIED BACK ONE YEAR INCOME PERMITTING.

      IF(TAPROF(I).GE.0.D0.OR. TAPROF(I-1).LE.0.D0)GO TO 1012
      TTPROF=TAPROF(I)+TAPROF(I-1)
      IF(TTPROF.LE.0.D0)GO TO 1013
      TAPROF(I-1)=TTPROF
      TAPROF(I)=0.D0
      IF(TTPROF.GT.35000.D0)GO TO 1300
      TAX(I-1)=0.22D0*TAPROF(I-1)
      GO TO 1012
1300  TTPROF=TTPROF-35000.D0
      TAX(I-1)=0.22D0*35000.D0+0.51D0*TTPROF
      GO TO 1012
1013  TAX(I-1)=0.D0
      TAPROF(I-1)=0.D0
      TAPROF(I)=TTPROF
1012  CONTINUE
      IF(TAPROF(I).LT.0.D0.OR.I.LE.IC)GO TO 1015
      PROF1=TAPROF(I)
C
C LOSSES FOR THE PREVIOUS FIVE YEARS CAN BE CARRIED FORWARD TO
C REDUCE TAXABLE INCOME.
C
      L=I-6
      IF(L.LT.0)L=0
1229  L=L+1
      IF(L.GE.I)GO TO 1226
      IF(TAXCAR(L).GE.0.D0)GO TO 1229
      IF(PROF1.LT.DABS(TAXCAR(L)))GO TO 1231
      PROF1=PROF1+TAXCAR(L)
      TAXCAR(L)=0.D0
      GO TO 1229
1231  TAXCAR(L)=TAXCAR(L)+PROF1
      PROF1=0.D0
1226  TAPROF(I)=PROF1
C
C THE FEDERAL TAX RATE ON INCOME UP TO THIRTY-FIVE THOUSAND DOLLARS
C IS ELEVEN PERCENT.
C
      IF(TAPROF(I).GT.35000.D0)GO TO 1014
      TAX(I)=0.22D0*TAPROF(I)
      GO TO 1001
1014  TAX(I)=0.22D0*35000.D0+0.51D0*(TAPROF(I)-35000.D0)
      GO TO 1001
1015  TAX(I)=0.D0
      IF(TAPROF(I).LT.0.D0)GO TO 1301
      XMPROF(I)=TAPROF(I)
      TAPROF(I)=0.D0
      GO TO 1001
C
C A TAXABLE LOSS IS CARRIED FORWARD.
C
1301  TAXCAR(I)=TAPROF(I)
1001  CONTINUE
```

```
      RETURN
C PRINT DETAILS OF THE TAX CALCULATION FOR THE OPTIMUM PROJECT.
      ENTRY PRNTAX
      PRINT1024
1024  FORMAT('1',53X,'INCOME TAX CALCULATION 1969',/,'+',53X,27('_'),/,
     *'-',16X,'GROSS',/,14X,'OPERATING',08X,'PROVINCIAL',8X,'INTEREST',
     *6X,'EXPLORATION',3X,'PREPRODUCTION',5X,'CAPITAL COST',5X,
     *'DEPLETION',/,15X,'PROFIT',11X,'ROYALTY',6X,'LONG TERM DEBT',
     *05X,'DEDUCTION',5X,'DEVELOPMENT',7X,'ALLOWANCE',7X,'ALLOWANCE',//)
      PRINT1025,(I,TGROPR(I),TOTROY(I),INTRST(I),XPLDED(I),PREALO(I),
     *NCCA(I),DEPLAL(I),I=1,N)
1025  FORMAT((1X,I2,8X,7(F16.5))/)
      PRINT1026
1026  FORMAT('1',//,13X,'TAX EXEMPT',08X,'TAXABLE',11X,'INCOME',7X,
     *'CUMULATIVE',4X,'UNDEP-BALANCE',3X,'UNDEP-BALANCE',5X,
     *'UNAMORTIZED',/,15X,'PROFIT',10X,
     *'PROFIT',13X,'TAX',09X,'EXPLORATION',3X,'PREPRO-DEVELOP',3X,
     *'NORMAL CCA',10X,'DEBT',//)
      PRINT1027,(I,XMPROF(I),TAPROF(I),TAX(I),CMXPLR(I),PREUB(I),
     *FIXUB(I),CAPUB(I),I=1,N)
1027  FORMAT((1X,I2,07X,7F16.5)/)
      RETURN
      END
```

```
THIS SUBROUTINE CALCULATES MANITOBA ROYALTY ASSESSMENTS AS OF 1977.
IT ADJUSTS THE ANNUAL DEPRECIATION RATES SO AS TO MINIMIZE THE
PRESENT VALUE OF THE ANNUAL ROYALTY PAYMENTS.

      SUBROUTINE ROYALT
      REAL*8 MSINV(50), CMPROC(50),PROFIT(50),R(50),S,DEPREC(50),DEXP,D,
     *GROPRO(50),TPROF,TPROBA,TBASRO,TINCRO,OLDROY,SUMROY,CAPTAX(50),T,
     *DISROY(50),BASROY(50),INCROY(50),PALLOW(50),ROYPRO(50),TOTROY(50),
     *PROBAS(50),TOTINV(50),TOTUB(50),MINUB(50),TAX(50),NETPRO,RI,W,U,
     *EXPLOR(2,50),PREPRO(2,50),MININV(2,50),PROINV(2,50),SOCINV(2,50),
     *WORCAP(50),INFLUB(50),DFLOAT,R1/0.15D0/,R2/0.35D0/,PA/0.08D0/
      INTEGER C,H,F,SET,Z
      COMMON GROPRO,MININV,PROINV,EXPLOR,SOCINV,PREPRO,TOTROY,TAX,
     *CAPTAX,WORCAP /B2/S,RI/B0/C,H,N/B9/IY//IQ
C
C 'U' IS THE MINIMUM ALLOWABLE DEPRECIATION RATE, INCOME PERMITTING.
C
      U=0.1D0-1.D-15
C
C THIS INTEGER WILL REMAIN SET TO ZERO UNTIL THE ROYALTY MINIMIZATION
C HAS BEEN COMPLETED.
C
      LET=0
C
C THIS INTEGER WILL BE SET TO A VALUE OF ONE EACH TIME A NEW DEPRECIATION
C RATE IS TESTED.
C
      SET=0
C
C THE NEXT FOUR VARIABLES DETERMINE THE NUMBER OF YEARS WHOSE DEPRECIATION
C RATES WILL BE INCLUDED IN THE MINIMIZATION PROCESS.
C 'H' IS THE LAST YEAR OF THE PREPRODUCTION PERIOD.
C
      K=H
C
C 'Z' IS THE NUMBER OF YEARS EXCLUDED FROM THE MINIMIZATION PROCESS
C AT THE END OF THE PRODUCTIVE LIFE OF THE PROJECT.
C
      Z=3
C
C 'M' IS THE LAST YEAR TO BE INCLUDED IN THE MINIMIZATION PROCEDURE.
C
      M=N-Z
C
C 'F' IS RANGE OF YEARS OVER WHICH THE ROYALTY RATE ADJUSTMENTS WILL
C TAKE PLACE.
C
      F=M-H
C
C FOR SMALL PROJECTS A DEPRECIATION ALLOWANCE WILL BE CLAIMED
C DURING THE PREPRODUCTION YEARS. THUS 'W' IS SET AT TWENTY PERCENT.
C
      W=0.D0
      IF(IQ.EQ.1)W=0.2D0
      DO 9000 I=1,H
      PALLOW(I)=0.D0
      ROYPRO(I)=0.D0
      TOTROY(I)=0.D0
      BASROY(I)=0.D0
      DISROY(I)=0.D0
      INCROY(I)=0.D0
```

```
      PROFIT(I)=0.D0
      R(I)=W
C
C DETERMINE THE MINING AND SEVICE INVESTMENT FOR EACH YEAR.
C
      MSINV(I)=MININV(1,I)+PREPRO(1,I)+EXPLOR(1,I)+SOCINV(1,I)
C
C DETERMINE THE TOTAL INVESTMENT FOR EACH YEAR.
C
9000  TOTINV(I)= MSINV(I)+PROINV(1,I)
      I=1
      PROBAS(I)=0.0D0
      TOTUB(I)=TOTINV(I)
C
C 'T' IS THE TOTAL ROYALTIES FORGONE AT THE TIME OF INVESTMENT BECAUSE
C A DEPRECIATION CLAIM CAN BE MADE AGAINST OTHER INCOME. ASSUME THE
C AVERAGE ROYALTY RATE IS FIFTEEN PERCENT.
C
      T=TOTUB(I)*W*R1
C
C FOR EACH CATEGORY OF CAPITAL ASSET THE NET COST TO THE FIRM IS
C REDUCED BY THE SAVING IN ROYALTIES.
C
      EXPLOR(2,I)=EXPLOR(2,I)-T*EXPLOR(1,I)/TOTINV(I)
      PREPRO(2,I)=PREPRO(2,I)-T*PREPRO(1,I)/TOTINV(I)
      MININV(2,I)=MININV(2,I)-T*MININV(1,I)/TOTINV(I)
      PROINV(2,I)=PROINV(2,I)-T*PROINV(1,I)/TOTINV(I)
      SOCINV(2,I)=SOCINV(2,I)-T*SOCINV(1,I)/TOTINV(I)
      DEPREC(I)=TOTUB(I)*W
      TOTUB(I)=TOTUB(I)-DEPREC(I)
      MINUB(I)= MSINV(I)*(1.D0-W)
C
C THE INVESTMENT BASE IS THE UNDEPRECIATED BALANCE OF MINING AND
C SERVICE ASSETS.
C
      INFLUB(I)=MINUB(I)
C
C THE ORIGINAL COST OF THE PROCESSING ASSETS IS RECORDED.
C
      CMPROC(I)=PROINV(1,I)
      DO 9001 I=2,H
      TOTUB(I)= TOTUB(I-1)+TOTINV(I)
      T=TOTUB(I)*W*R1
      EXPLOR(2,I)=EXPLOR(2,I)-T*EXPLOR(1,I)/TOTINV(I)
      PREPRO(2,I)=PREPRO(2,I)-T*PREPRO(1,I)/TOTINV(I)
      MININV(2,I)=MININV(2,I)-T*MININV(1,I)/TOTINV(I)
      PROINV(2,I)=PROINV(2,I)-T*PROINV(1,I)/TOTINV(I)
      SOCINV(2,I)=SOCINV(2,I)-T*SOCINV(1,I)/TOTINV(I)
      DEPREC(I)=TOTUB(I)*W
      TOTUB(I)=TOTUB(I)-DEPREC(I)
      MINUB(I)=(MINUB(I-1)+ MSINV(I))*(1.D0-W)
C
C THE INVESTMENT BASE IS INCREASED BECAUSE OF INFLATION AND NEW INVESTMENT.
C IT IS DECREASED WHEN DEPRECIATION IS CLAIMED.
C
      INFLUB(I)=(INFLUB(I-1)*(1.D0+RI)+MSINV(I))*(1.D0-W)
      CMPROC(I)=CMPROC(I-1)+PROINV(1,I)
C
C THE PROFIT BASE IS EIGHTEEN PERCENT OF THE INVESTMENT BASE FOR
C THE PREVIOUS YEAR.
C
9001  PROBAS(I)=0.18D0*INFLUB(I-1)
```

```
C FOR PROJECTS WITH A SHORT LIFE IT IS POSSIBLE TO DEPRECIATE THE ASSETS
C AT A RATE IN EXCESS OF TWENTY PERCENT. ONLY TWENTY PERCENT IS USED
C IN THIS STUDY.
C
      IS=N-H-IY
      T=2.D0/DFLOAT(IS)
      IF(T.LT.0.2D0)T=0.2D0
      IF(T.GT.0.6D0)T=0.6D0
      T=0.2D0
C
C SET ALL THE DEPRECIATION RATES AT THE MAXIMUM VALUE.
C
      DO 9002 I=C,N
 9002 R(I)=T
C
C 'D' IS THE AMOUNT BY WHICH THE DEPRECIATION RATES WILL BE CHANGED
C DURING THE OPTIMIZING PRODEDURE.
C
      D=0.010D0
      OLDROY=1.0D+12
C
C THE ROYALTY MINIMIZING PROCEDURE BEGINS HERE.
C
 9003 CONTINUE
      SUMROY=0.D0
      DO 9005 I=C,N
C
C DEDUCT CURRENT EXPLORATION COSTS FROM INCOME.
C
      PROFIT(I)=GROPRO(I)-EXPLOR(2,I)
      IF(PROFIT(I).LT.0.D0)PROFIT(I)=0.D0
      MSINV(I)=MININV(2,I)+SOCINV(2,I)
      TOTINV(I)= MSINV(I)+PROINV(2,I)
      TOTUB(I)=TOTUB(I-1)+TOTINV(I)
      MINUB(I)=MINUB(I-1)+MSINV(I)
      INFLUB(I)=INFLUB(I-1)*(1.D0+RI)+MSINV(I)
      CMPROC(I)=CMPROC(I-1)+PROINV(2,I)
C
C WITHIN THE LAST THRE YEARS OF PRODUCTION USE THE MAXIMUM DEPRECIATION RATE.
C
      IF(I.GT.M)R(I)=T
      DEPREC(I)=R(I)*TOTUB(I)
      IF(DEPREC(I)-PROFIT(I))9006,9041,9041
 9041 DEPREC(I)=PROFIT(I)
      R(I)=DEPREC(I)/TOTUB(I)
 9006 NETPRO=PROFIT(I)-DEPREC(I)
C
C CALCULATE THE PROCESSING ALLOWANCE.
C
      PALLOW(I)=CMPROC(I)*PA
      IF(PALLOW(I).LE.0.50D0*NETPRO)GO TO 9007
      PALLOW(I)=0.50D0*NETPRO
 9007 ROYPRO(I)=NETPRO-PALLOW(I)
      PROBAS(I)=0.18D0*INFLUB(I-1)
C
C EVERY THIRD YEAR THE ROYALTIES FOR THE THREE YEAR PERIOD ARE AVERAGED.
C
      IF((I-H)/3*3.NE.(I-H))GO TO 9009
      TPROF=ROYPRO(I)+ROYPRO(I-1)+ROYPRO(I-2)
      TPROBA=PROBAS(I)+PROBAS(I-1)+PROBAS(I-2)
      IF(TPROF.GT.TPROBA)GO TO 9010
```

```
      TBASRO=R1*TPROF
      TINCRO=0.D0
      GO TO 9011
9010  TBASRO=R1*TPROBA
      TINCRO=R2*(TPROF-TPROBA)
9011  BASROY(I)=TBASRO-BASROY(I-1)-BASROY(I-2)
      INCROY(I)=TINCRO-INCROY(I-1)-INCROY(I-2)
      GO TO 9012
9009  CONTINUE
C
C CALCULATE THE BASE AND INCREMENTAL ROYALTIES.
C
      IF(ROYPRO(I).GT.PROBAS(I))GO TO 9013
      BASROY(I)=R1*ROYPRO(I)
      INCROY(I)=0.D0
      GO TO 9012
9013  BASROY(I)=R1*PROBAS(I)
      INCROY(I)=R2*(ROYPRO(I)-PROBAS(I))
9012  TOTROY(I)=BASROY(I)+INCROY(I)
C
C DISCOUNT THE TOTAL ROYALTY TO THE BEGINNING OF THE FIRST YEAR.
C
      DISROY(I)=TOTROY(I)*(DEXP(S)-1.0D0+1.D-15)/(S*DEXP(S*I)+1.D-15)
C
C REDUCE THE INVESTMENT BASE, THE MINE AND SERVICE UNDEPRECIATED BALANCE,
C AND THE TOTAL UNDEPRECIATED BALANCE BY THE DEPRECIATION CLAIMED.
C
      INFLUB(I)=INFLUB(I)*(1.D0-R(I))
      MINUB(I)=MINUB(I)*(1.D0-R(I))
      TOTUB(I)=TOTUB(I)-DEPREC(I)
C
C ADD THE CURRENT DISCOUNTED ROYALTY TO THE TOTAL TO DATE.
C
      SUMROY=SUMROY+DISROY(I)
9005  CONTINUE
C
C IF THE PROJECT PRODUCTIVE LIFE IS TOO SHORT, OR THE DISCOUNTED ROYALTIES
C ARE NEGATIVE,OR THE MINIMIZATION PROCEDURE IS COMPLETED GO TO THE
C END OF THE PROGRAM.
C
      IF((N-H).LE.Z.OR.SUMROY.LE.0.D0.OR.LET.NE.0)GO TO 9004
C
C IF THE CURRENT SIMULATION DOES NOT RESULT IN A REDUCED TOTAL ROYALTY
C DO NOT RECORD IT. IF IT DOES, RECORD THE AMOUNT AND SET THE STEP COUNTER
C TO ZERO.
C
      IF(OLDROY.LE.SUMROY)GO TO 9018
      OLDROY=SUMROY
      L=0
C
C PROCEED TO WHERE THE DEPRECIATION RATE FOR THE FOLLOWING YEAR CAN
C BE REDUCED BY ONE PERCENT.
C
      GO TO 9019
9018  CONTINUE
C
C IF THE DEPRECIATION RATE FOR THE CURRENT YEAR HAD BEEN REDUCED BY ONE
C PERCENT RETURN IT TO IT'S PREVIOUS VALUE. OTHERWISE MOVE ON TO THE NEXT YEAR.
C
      IF(SET.NE.1)GO TO 9019
      R(K)=R(K)+D
9019  K=K+1
```

```
      L=L+1

 THIS INTEGER WILL REMAIN AT ZERO UNTIL THE DEPRECIATION RATE FOR
 THE CURRENT YEAR IS REDUCED BY ONE PERCENT.

      SET=0

 IF ALL THE DEPRECIATION RATES OVER THE RELEVANT RANGE OF YEARS
 HAVE NOT BEEN TESTED WITHOUT AT LEAST ONE SIMULATION RESULTING IN A
 REDUCTION IN TOTAL ROYALTIES PROCEED TO THE FOLLOWING YEAR.
 IF ALL YEARS HAVE BEEN TESTED AND NO FUTHER REDUCTION IN TOTAL
 ROYALTIES IS POSSIBLE THE PROCEDURE IS COMPLETED.

      IF(L.LE.F)GO TO 9020
      LET=1
      GO TO 9003
 020  CONTINUE

 IF THE NEW POSSIBLE DEPRECIATION RATE IS LESS THAN THE MINIMUM PERMITTED
 AND THE LAST YEAR IN THE RELEVANT RANGE OF YEARS HAS NOT BEEN REACHED
 PROCEED TO THE NEXT YEAR.

      IF( R(K)-D.GE.U.OR.K.GT.M)GO TO 9021
      L=L+1
      K=K+1
      GO TO 9020
9021  CONTINUE
C
C IF THE RELEVANT RANGE OF YEARS HAS NOT BEEN EXCEEDED PROCEED TO WHERE THE
C DEPRECIATION RATE CAN BE REDUCED. OTHERWISE BEGIN AGAIN AT THE FIRST
C YEAR OF PRODUCTION.
C
      IF(K.LE.M)GO TO 9022
      K=C
9022  CONTINUE
C
C IF THE NEW POSSIBLE DEPRECIATION RATE EXCEEDS THE MINIMUM ALLOWED
C REDUCE THE EXISTING RATE BY ONE PERCENT.
C
      IF(R(K)-D.LT.U)GO TO 9003
      R(K)=R(K)-D
C
C THIS INTEGER IS SET TO A VALUE OF ONE TO INDICATE THAT A NEW
C VARIATION IS BEING TRIED.
C
      SET=1
      GO TO 9003
9004  CONTINUE
      RETURN
C
C PRINT THE DETAILED ROYALTY CALCULATION FOR THE OPTIMUM PROJECT.
C
      ENTRY PRNROY
      PRINT9030
9030  FORMAT('1',54X,'ROYALTY MINIMIZATION',/,'+',54X,20('_'),/,
     *'-',9X,'PROFIT',10X,'ANNUAL', 8X,'PROCESSING',7X,'ROYALTY',09X,
     *'PROFIT',12X,'BASIC',8X,'INCREMENTAL',8X,'TOTAL',/,
     *6X, 'AFTER EXPLOR',4X,'DEPRECIATION',6X,'ALLOWANCE',08X,'PROFIT',
     *8X,'BASE  (18%)',9X,'ROYALTY',9X,'ROYALTY',08X,'ROYALTY',//)
      PRINT9031,(I,PROFIT(I),DEPREC(I),PALLOW(I),ROYPRO(I),PROBAS(I),
     *BASROY(I),INCROY(I),TOTROY(I),I=1,N)
9031  FORMAT((1X,I2,1X,8(F16.5))/)
```

```
      PRINT9032
 032  FOPMAT('1',///,9X,'YEARLY',7X,'MINING AND',6X,'CUMULATIVE',11X,
     *'ANNUAL',07X,'ANNUAL',10X,'TOTAL',8X,'MINE AND SERVICE',3X,
     *'INFLATED',/,
     *' ',6X,'GROSS INVEST',2X,'SERVICE INVEST',3X,'PROCESS INVEST',5X,
     *'DEPREC RATE',2X,'DEPRECIATION',2X,'UNDEPREC BALANCE',
     *1X,'UNDEPREC BALANCE',1X,'UNDEPREC BALANC',//)
      PRINT9033,(I,TOTINV(I), MSINV(I),CMPROC(I),R(I),DEPREC(I),TOTUB(I)
     *,MINUB(I),INFLUB(I),I=1,N)
)033  FORMAT((1X,I2,1X,3(F16.5),F16.12,4(F16.5))/)
      PRINT9034,S
)034  FORMAT(//,11X,'1 THE OPPORTUNITY COST OF CAPITAL IS',F6.2,'%.')
      RETURN
      END
```

```
C THIS SUBROUTINE CALCULATES TOTAL INCOME TAX ASSESSMENTS AS OF 1977.
C
      SUBROUTINE INCTAX
      REAL*8 GROPRO(50),FIXINV(50),WORCAP(50),INFLA2(50),BORCAP(50),
     *ONGINV(50),FIXUB(50),PREUB(50),DEPLUB(50),CAPUB(50),INTRST(50),
     *ONGUB(50),RALLOW(50),TAPROF(50),TAX(50),PRIN(50),SM,SC,SV,TL,TK,
     *DER,NCCA(50),ACCA(50),DEPLAL(50),ACCWOR(50),  PROF1,EXP,TTPROF,S,
     *FIXCAP(50),PRECAP(50),TOTROY(50),CMXPLR(50),XPLCAP(50),XPLDED(50),
     *EXPLOR(2,50),PREPRO(2,50),MININV(2,50),PROINV(2,50),SOCINV(2,50),
     *DABS,PREALO(50),TAXCAR(50),EQUITY(50),CAPTAX(50),TGROPR(50),AD,AE,
     *CR(50),TCX,TC,CT,CX,AC,FT,RC
      INTEGER C,D
      COMMON GROPRO,MININV,PROINV,EXPLOR,SOCINV,PREPRO,TOTROY,TAX,
     *CAPTAX,WORCAP /B1/INFLA2/B3/TL/B4/INTRST,PRIN,S
     */B5/BORCAP,DER,SM,SC/B9/IY/B11/CAPUB/B0/C,D,N//IQ
C
C SET THE TAX CREDIT RATE.
C
      RC=0.05D0
C
C THESE VARIABLES RECORD THE TOTAL TAX CREDITS AND THE AMOUNT
C CLAIMED RESPECTIVELY.
C
      CT=0.D0
      CX=0.D0
C
C THESE VARIABLES WILL DETERMINE THE AMOUNT OF THE CAPITAL COST
C ALLOWANCES DURING THE PREPRODUCTION PHASE OF THE PROJECT.
C THE VALUES ASSIGNED HERE ARE FOR LARGE INDEPENDANT PROJECTS
C WHERE THE INVESTMENT IS RECOVERED AFTER PRODUCTION BEGINS.
C
      AD=0.D0
      AE=0.D0
      AC=1.D0
C
C FOR SMALL PROJECTS CAPITAL COSTS ARE PARTIALLY RECOVERED
C FROM OTHER INCOME. 'IQ' WILL EQUAL '1' IF THIS IS THE CASE.
C
      IF(IQ.EQ.0)GO TO 1090
      AD=0.3D0
      AE=1.0D0
      AC=0.D0
 1090 CONTINUE
      DO 1100 I=1,D
      TAX(I)=0.D0
      TAPROF(I)=0.D0
      RALLOW(I)=0.D0
      ONGINV(I)=0.D0
      TGROPR(I)=0.D0
      DEPLAL(I)=0.D0
      ONGUB  (I)=0.D0
      NCCA(I)=0.D0
      PRIN(I)=0.D0
      INTRST(I)=0.D0
      FIXINV(I)=MININV(1,I)+PROINV(1,I)+SOCINV(1,I)
C
C DETERMINE THE AMOUNT OF THE TAX CREDIT.
C
      CR(I)=FIXINV(I)*RC
      CT=CT+CR(I)
      CR(I)=AC*CR(I)
```

```
C
C DETERMINE THE AMOUNT OF BORROWED CAPITAL FOR EACH YEAR OF THE
C PREPRODUCTION PERIOD.
C
  100 BORCAP(I)=(FIXINV(I)+PREPRO(1,I)+EXPLOR(1,I)+WORCAP(I))*DER
      I=1
C
C ADD INTEREST TO THE CAPITAL BORROWED.
C
      CAPUB (I)=BORCAP(I)*(1.D0+S)
C
C THE INTEREST IS CAPITALIZED AND WILL LATER REDUCE THE TAXABLE INCOME
C WHEN A CAPITAL COST ALLOWANCE IS CLAIMED.
C
      FIXCAP(I)=FIXINV(I)*DEP*(1.D0+S)
      PRECAP(I)=PREPRO(1,I)*DER*(1.D0+S)
      XPLCAP(I)=EXPLOR(1,I)*DER*(1.D0+S)
C
C THE ASSET POOL FOR PURPOSES OF THE CAPITAL COST ALLOWANCE IS
C INCREASED BY THE AMOUNT OF THE INTEREST. IT IS DECREASED BY THE TAX
C CREDIT CLAIMED AGAINST THE TAX PAYABLE ON OTHER INCOME.
C
      FIXUB (I)=FIXINV(I)*(1.D0+DER*S-RC*AE)
C
C THE CAPITAL COST ALLOWANCE WILL EITHER BE A TAXABLE LOSS AND
C CARRIED FORWARD OR CLAIMED AGAINST OTHER INCOME.
C
      ACCA(I)=0.3D0*FIXUB(I)
C
C REDUCE THE UNDEPRECIATED BALANCE BY THE AMOUNT OF THE CAPITAL COST
C ALLOWANCE CLAIM.
C
      FIXUB(I)=FIXUB(I)-ACCA(I)
C
C THE NET COST TO THE FIRM FOR ANY CATEGORY OF ASSET IS
C REDUCED BY THE TAX SAVING AT THE TIME OF INVESTMENT.
C
      MININV(2,I)=MININV(2,I)-AE*(ACCA(I)*0.51D0*MININV(1,I)/FIXINV(I)+
     *RC*MININV(1,I))
      PROINV(2,I)=PROINV(2,I)-AE*(ACCA(I)*0.51D0*PROINV(1,I)/FIXINV(I)+
     *RC*PROINV(1,I))
      SOCINV(2,I)=SOCINV(2,I)-AE*(ACCA(I)*0.51D0*SOCINV(1,I)/FIXINV(I)+
     *RC*SOCINV(1,I))
      PREUB(I)=PREPRO(1,I)*(1.D0+DER*S)
      PREALO(I)=PREUB(I)*AD
      PREPRO(2,I)=PREPRO(2,I)-PREALO(I)*0.51D0
      PREUB(I)=PREUB(I)*(1.D0-AD)
      CMXPLR(I)=EXPLOR(1,I)*(1.D0+DER*S)
      XPLDED(I)=CMXPLR(I)*AE
      EXPLOR(2,I)=EXPLOR(2,I)-XPLDED(I)*0.51D0
      CMXPLR(I)=CMXPLR(I)*(1.D0-AE)
C
C CALCULATE THE AMOUNT OF THE EARNED DEPLETION BANK.
C
      DEPLUB(I)=(FIXINV(I)+PREPRO(1,I)+EXPLOR(1,I))/3.D0
C
C CALCULATE THE CAPITAL TAX.
C
      ACCWOR(I)=WORCAP(I)
      EQUITY(I)=(1.0D0-DER)*(FIXINV(I)+PREPRO(1,I)+EXPLOR(1,I))
      CAPTAX(I)=0.002D0*(CAPUB(I)+EQUITY(I)+ACCWOR(I))
      CAPTAX(I)=0.D0
```

```
C THE CAPITAL TAX AND CAPITAL COST ALLOWANCE CONSTITUTE A LOSS CARRYFORWARD.
C
      TAXCAR(I)=-CAPTAX(I)-ACCA(I)*AC
      TAPROF(I)=TAXCAR(I)
      DO 1000 I=2,D
C
C THE TOTAL BORROWED CAPITAL IS THE AMOUNT OWING FROM THE PREVIOUS YEAR
C PLUS THE  AMOUNT BORROWED THIS YEAR PLUS THE CURRENT INTEREST ON THE TOTAL.
C
      CAPUB  (I)=(BORCAP(I)+CAPUB  (I-1))*(1.D0+S)
      FIXCAP(I)=FIXINV(I)*DER*(1.D0+S)+FIXCAP(I-1)*(1.D0+S)
      PRECAP(I)=PREPRO(1,I)*DER*(1.D0+S)+PRECAP(I-1)*(1.D0+S)
      XPLCAP(I)=EXPLOR(1,I)*DER*(1.D0+S)+XPLCAP(I-1)*(1.D0+S)
C
C THE UNDEPRECIATED BALANCE IS THE SUM OF CURRENT INVESTMENT PLUS
C INTEREST ON THE AMOUNT BORROWED PLUS INTEREST ON THE CAPITAL PREVIOUSLY
C BORROWED PLUS THE PREVIOUS UNDEPRECIATED BALANCE. A REDUCTION IS MADE
C FOR ANY TAX CREDIT CLAIM.
C
      FIXUB  (I)=FIXINV(I)*(1.D0+DER*S-RC*AE)+FIXCAP(I-1)*S+FIXUB(I-1)
      ACCA(I)=0.3D0*FIXUB(I)
      FIXUB(I)=FIXUB(I)-ACCA(I)
C
C NET COST TO THE FIRM IS REDUCED BY THE TAX SAVING.
C
      MININV(2,I)=MININV(2,I)-AE*(ACCA(I)*0.51D0*MININV(1,I)/FIXINV(I)+
     *RC*MININV(1,I))
      PROINV(2,I)=PROINV(2,I)-AE*(ACCA(I)*0.51D0*PROINV(1,I)/FIXINV(I)+
     *RC*PROINV(1,I))
      SOCINV(2,I)=SOCINV(2,I)-AE*(ACCA(I)*0.51D0*SOCINV(1,I)/FIXINV(I)+
     *RC*SOCINV(1,I))
      PREUB(I)=PREPRO(1,I)*(1.D0+DER*S)   +PRECAP(I-1)*S+PREUB(I-1)
      PREALO(I)=PREUB(I)*AD
      PREPRO(2,I)=PREPRO(2,I)-PREALO(I)*0.51D0
      PREUB(I)=PREUB(I)*(1.D0-AD)
      CMXPLR(I)=EXPLOR(1,I)*(1.D0+DER*S)  +XPLCAP(I-1)*S+CMXPLR(I-1)
      XPLDED(I)=CMXPLR(I)*AE
      EXPLOR(2,I)=EXPLOP(2,I)-XPLDED(I)*0.51D0
      CMXPLR(I)=CMXPLR(I)*(1.D0-AE)
C
C CALCULATE THE CAPITAL TAX AND CARRY IT FORWARD AS A TAXABLE LOSS.
C
      ACCWOR(I)=ACCWOR(I-1)+WORCAP(I)
      EQUITY(I)=EQUITY(I-1)+(1.D0-DER)*(FIXINV(I)+PREPRO(1,I)+
     *EXPLOR(1,I))
      CAPTAX(I)=0.002D0*(CAPUB(I)+EQUITY(I)+ACCWOR(I))
      CAPTAX(I)=0.D0
      TAXCAR(I)=-CAPTAX(I)-ACCA(I)*AC
      TAPROF(I)=TAXCAR(I)
C
C INCREASE THE EARNED DEPLETION BANK.
C
1000  DEPLUB(I)=(FIXINV(I)+PREPRO(1,I)+EXPLOR(1,I))/3.D0+DEPLUB(I-1)
C
C DETERMINE THE ANNUAL INTEREST PAYMENTS AND THE AMOUNT TO BE PAID
C ON THE PRINCIPAL.
C
      CALL DEBT
C
C IN THE FINAL YEAR OF PRODUCTION THIS WILL BE A FRACTION THAT
C WILL LIMIT THE AMOUNT OF THE DEPRECIATION CLAIM.
```

```
      TK=1.D0
      DO 1001 I=C,N
      IF(I.EQ.N)TK=TL
      ACCA(I)=0.D0
      NCCA(I)=0.D0
      XPLDED(I)=0.D0
      DEPLAL(I)=0.D0
      TAXCAR(I)=0.D0
      PPEALO(I)=0.D0
      RALLOW(I)=0.D0
      CR(I)=0.D0
C
C ONGOING INVESTMENT IS THE SUM OF THE INVESTMENT IN MINING,
C PROCESSING, AND SERVICE ASSETS.
C
      ONGINV(I)=MININV(2,I)+PROINV(2,I)+SOCINV(2,I)
      ONGUB(I)=ONGUB(I-1)+ONGINV(I)
      PREUB(I)=PREUB(I-1)+PREPRO(2,I)
      FIXINV(I)=0.D0
      FIXUB(I)=FIXUB(I-1)+FIXINV(I)
      DEPLUB(I)=DEPLUB(I-1)+EXPLOR(2,I)/3.D0
      CMXPLR(I)=CMXPLR(I-1)+EXPLOR(2,I)
C
C CALCULATE THE CAPITAL TAX.
C
      ACCWOR(I)=(WORCAP(D)/INFLA2(D)+WORCAP(C)/INFLA2(C))*INFLA2(I)
      EQUITY(I)=EQUITY(D)*INFLA2(I)/INFLA2(D)-(I-D)*EQUITY(D)/ (N-D-IY)
     **INFLA2(I)/INFLA2(D)+ONGUB(I)
      IF(EQUITY(I).LT.0.D0)EQUITY(I)=0.D0
      IF(IY.GE.1)EQUITY(N)=0.D0
      IF(IY.GE.1)ACCWOR(N)=0.D0
      CAPTAX(I)=0.002D0*(CAPUB(I)+EQUITY(I)+ACCWOR(I))
      CAPTAX(I)=0.D0
      TGROPR(I)=GROPRO(I)-CAPTAX(I)
      IF(I.NE.N)GO TO 1060
C
C IN THE FINAL YEAR OF PRODUCTION ASSET SALVAGE VALUE CAN REDUCE THE
C UNDEPRECIATED BALANCE OF THE FIXED INVESTMENT. ANY REMAINING VALUE
C IS ADDED TO INCOME.
C
      SV=SM+SC
      IF(SV-ONGUB(I))1061,1061,1062
1061  ONGUB(N)=ONGUB(N)-SV
      GO TO 1060
1062  SV=SV-ONGUB(N)
      ONGUB(N)=0.D0
      TGROPR(N)=TGROPR(N)+SV
1060  PROF1=TGROPR(I)
      IF(PROF1.GT.0.D0)GO TO 1224
C
C IF THERE IS NO INCOME THE THE MINIMUM CAPITAL COST ALLOWANCE IS
C CLAIMED AND BECOMES A LOSS CARRY-FORWARD.
C
      ACCA(I)=0.3D0*FIXUB(I)
      FIXUB(I)=FIXUB(I)-ACCA(I)
      PROF1=PROF1-ACCA(I)-INTRST(I)
      GO TO 1002
1224  TCX=0.D0
C
C DETERMINE THE AMOUNT OF THE ALLOWANCE FOR THE RECOVERY OF PREPRODUCTION
C DEVELOPMENT COSTS.
```

```
      IF(PREUB(I).GT.0.D0)PREALO(I)=0.3D0*PREUB(I)

 DETERMINE THE TOTAL LOSSES FOR THE PREVIOUS FIVE YEARS.

      L=I-6
      IF(L.LT.0)L=0
 140  L=L+1
      IF(L.GE.I)GO TO 1141
      TCX=TCX-TAXCAR(L)
      GO TO 1140

 DETERMINE THE TOTAL DEDUCTIONS THAT COULD BE MADE FOLLOWING THE
 INVESTMENT ALLOWANCE. DIVIDE THIS BY .75 .ANY PROFIT IN EXCESS OF THIS
 CAN BE USED FOR THE CAPITAL COST ALLOWANCES.

 141  EXP=(INTRST(I)+PREALO(I)+CMXPLR(I)+TCX)/0.75D0
      IF(EXP.LT.PROF1)GO TO 1003

 CALCULATE A RESOURCE ALLOWANCE WITHOUT DEDUCTING A CAPITAL COST ALLOWANCE.

      RALLOW(I)=0.25D0*PROF1

 DEDUCT THE RESOURCE ALLOWANCE AND INTEREST.

      PROF1=PROF1-RALLOW(I)-INTRST(I)
      IF(PROF1.LE.0.D0)GO TO 1002
C
C DEDUCT THE PREPRODUCTION DEVELOPMENT ALLOWANCE.
C
      IF(PROF1.GT.PREALO(I))GO TO 1051
      PREALO(I)=PROF1
      PREUB(I)=PREUB(I)-PREALO(I)
      PROF1=0.D0
      GO TO 1002
1051  PROF1=PROF1-PREALO(I)
      PREUB(I)=PREUB(I)-PREALO(I)
C
C INCOME IS REDUCED BY THE FULL AMOUNT OF EXPLORATION COSTS.
C
      IF(PROF1.GT.CMXPLR(I))GO TO 1052
      XPLDED(I)=PROF1
      PROF1=0.D0
      GO TO 1053
1052  XPLDED(I)=CMXPLR(I)
      PROF1=PROF1-XPLDED(I)
1053  CMXPLR(I)=CMXPLR(I)-XPLDED(I)
      GO TO 1002
C
C DETERMINE THE PROFIT WHICH CAN BE USED FOR CAPITAL COST ALLOWANCES.
C
1003  PROF1=PROF1-EXP
C
C ONGOING INVESTMENT IS RECOVERED AT THIRTY PERCENT OF THE UNCLAIMED BALANCE.
C
      NCCA(I)=0.3D0*ONGUB(I)*TK
      IF(PROF1.GT.NCCA(I))GO TO 1008
      ONGUB(I)=ONGUB(I)-PROF1
      NCCA(I)=PROF1
      PROF1=0.D0
      GO TO 1009
1008  PROF1=PROF1-NCCA(I)
```

```
      ONGUB(I)=ONGUB(I)-NCCA(I)
 009  CONTINUE

 DETERMINE THE ACCELERATED CALITAL COST ALLOWANCE.

      IF(PROF1.GT.FIXUB(I))GO TO 1010
      FIXUB(I)=FIXUB(I)-PROF1
      ACCA(I)=PROF1
      PROF1=0.D0
      GO TO 1011
 010  PROF1=PROF1-FIXUB(I)
      ACCA(I)=FIXUB(I)
      FIXUB(I)=0.D0
 011  PROF1=PROF1+EXP
:
: CALCULATE THE RESOURCE ALLOWANCE ON THE PROFIT AFTER THE CAPITAL
: COST ALLOWANCES.
:
      RALLOW(I)=0.25D0*PROF1
      PROF1=PROF1-RALLOW(I)-INTRST(I)-PREALO(I)-CMXPLR(I)
      XPLDED(I)=CMXPLR(I)
      CMXPLR(I)=0.D0
      PREUB(I)=PREUB(I)-PREALO(I)
      IF(DEPLUB(I).LE.0.D0.OR.PROF1.LE.0.D0)GO TO 1002
C
C CALCULATE THE EARNED DEPLETION ALLOWANCE ON PROFIT AFTER ALLOWING FOR
C THE CARRY FORWARD OF LOSSES.
C
      DEPLAL(I)=0.25D0*(PROF1-TCX)
      IF(DEPLAL(I).GE.DEPLUB(I))GO TO 1006
      DEPLUB(I)=DEPLUB(I)-DEPLAL(I)
      GO TO 1007
1006  DEPLAL(I)=DEPLUB(I)
      DEPLUB(I)=0.D0
1007  PROF1=PROF1-DEPLAL(I)
1002  TAPROF(I)=PROF1
C
C A TAXABLE LUSS CAN BE CARRIED BACK ONE YEAR INCOME PERMITTING.
C
      IF(TAPROF(I).GE.0.D0.OR. TAPROF(I-1).LE.0.D0)GO TO 1012
      TTPROF=TAPROF(I)+TAPROF(I-1)
      IF(TTPROF.LE.0.D0)GO TO 1013
      TAX(I-1)=0.51D0*TTPROF
      TAPROF(I-1)=TTPROF
      TAPROF(I)=0.D0
      GO TO 1012
1013  TAX(I-1)=0.D0
      TAPROF(I-1)=0.D0
      TAPROF(I)=TTPROF
1012  CONTINUE
      IF(TAPROF(I).LE.0.D0)GO TO 1015
C
C LOSSES FOR THE PREVIOUS FIVE YEARS CAN BE CARRIED FORWARD TO
C REDUCE TAXABLE INCOME.
C
      L=I-6
      IF(L.LT.0)L=0
1229  L=L+1
      IF(L.GE.I)GO TO 1226
      IF(TAXCAR(L).GE.0.D0)GO TO 1229
      IF(TAPROF(I).LT.DABS(TAXCAR(L)))GO TO 1231
      TAPROF(I)=TAPROF(I)+TAXCAR(L)
```

```
      TAXCAR(L)=0.D0
      GO TO 1229
1231  TAXCAR(L)=TAXCAR(L)+TAPROF(I)
      TAPROF(I)=0.D0
C
C CALCULATE THE FEDERAL AND PROVINCIAL INCOME TAX PAYABLE.
C
1226  TAX(I)=0.51D0*TAPROF(I)
      IF(IQ.EQ.1.OR.RC.EQ.0.D0.OR.DABS(CX-CT).LT.0.1D0)GO TO 1001
C
C REDUCE THE AMOUNT OF THE FEDERAL TAX BY THE TAX CREDIT.
C
      FT=TAX(I)*0.36D0/0.51D0
      IF(FT-15000.D0)1128,1128,1125
1128  TC=FT
      GO TO 1127
1125  TC=15000.D0+0.5D0*(FT-15000.D0)
1127  TCX=TC
      L=I-6
      IF(L.LT.0)L=0
1129  L=L+1
      IF(L.GE.I)GO TO 1126
      IF(CR(L).LE.0.D0)GO TO 1129
      IF(CR(L).GE.TC)GO TO 1131
      TC=TC-CR(L)
      PREUB(I)=PREUB(I)-CR(L)
      CR(L)=0.D0
      GO TO 1129
1131  CR(L)=CR(L)-TC
C
C REDUCE THE UNDEPRECIATED BALANCE OF THE PREPRODUCTION DEVELOPMENT
C COSTS BY THE AMOUNT OF THE TAX CREDIT.
C
      PREUB(I)=PREUB(I)-TC
      TC=0.D0
1126  TAX(I)=TAX(I)-TCX+TC
      CX=CX+TCX-TC
      GO TO 1001
1015  TAX(I)=0.D0
C
C A TAXABLE LOSS IS CARRIED FORWARD.
C
      TAXCAR(I)=TAPROF(I)
1001  CONTINUE
      RETURN
C
C PRINT DETAILS OF THE TAX CALCULATION FOR THE OPTIMUM PROJECT.
C
      ENTRY PRNTAX
      PRINT 202
202   FORMAT('1',///,47X,'CAPITAL TAX CALCULATION',/,'+',46X,23('_'))
      PRINT203
203   FORMAT(///,25X,'UNAMORTIZED',12X,'EQUITY',12X,'ACCUMULATED',11X,
     *'CAPITAL',/,28X,'DEBT',16X,'CAPITAL',09X,'WORKING CAPITAL',11X,
     *'TAX')
      PRINT204,(I,CAPUB(I),EQUITY(I),ACCWOR(I),CAPTAX(I),I=1,N)
204   FORMAT(/ ,5X,I2,10X,4F20.5)
      PRINT1024
1024  FORMAT('1',50X,'INCOME TAX CALCULATION 1977',/,'+',50X,27('_'),/,
     *'-',5X,'GROSS PROFIT',06X,'ACCELERATED',6X,'NORMAL',/,9X,'AFTER',
     *              9X,'CAPITAL COST',4X,'CAPITAL COST',6X,'RESOURCE',
     *5X,'INTEREST ON',6X,'EXPLORATION',3X,'PREPROD-DEVELOP',4X,
```

```
     *'DEPLETION',/,6X,'CAPITAL TAX',      7X,'ALLOWANCE',7X,'ALLOWANCE',
     *7X,'ALLOWANCE',4X,'LONG TERM DEBT',5X,'DEDUCTION',7X,
     *'ALLOWANCE',   7X,'ALLOWANCE',//)
      PRINT1025,(I,TGROPR(I),ACCA(I),NCCA(I),RALLOW(I),INTRST(I),
     *XPLDED(I),PREALO(I),DEPLAL(I),I=1,N)
 025  FORMAT((1X,I2,1X,8(F16.5))/)
      PRINT1026
 026  FORMAT('1',/,3X,'TAXABLE PROFIT(LOSS)',2X,'INCOME',7X,
     *'UNDEP-BALANCE',
     *4X,'UNDEP-BALANCE',4X,'UNAMORTIZED',4X,'CUMULATIVE',5X,
     *'UNDEP-BALANCE',4X,'UNDEP-BALANCE',/,4X, 'AFTER PRIOR LOSSES',4X,
     *'TAX',09X,'ACCEL-CCA',8X,'NORMAL CCA',9X,    'DEBT',
     *8X,'EXPLORATION', 4X,'PREPRO-DEVELOP',4X,'DEPLETION',//)
      PRINT1027,(I,TAPROF(I),TAX(I),FIXUB(I),ONGUB(I),CAPUB(I),C
     *MXPLR(I),PREUB(I),DEPLUB(I),I=1,N)
 027  FORMAT((1X,I2,1X,8(F16.5))/)
      IF(IG.EQ.1)CX=CT
      PRINT 1028,CT,CX
 028  FORMAT(///,20X,'TOTAL TAX CREDITS AMOUNTED TO',1X,F15.5,1X,'$.',/,
     *20X,'CREDITS USED AMOUNTED TO',6X,F15.5,1X,'$.')
      RETURN
      END
```

APPENDIX II

EXAMPLE, PROJECT #1, EXPERIMENT #7

INPUT DATA

THREE OPTIONS CARDS

0.48210	0.0	0.06860	0.01450	0.03800	0.02230

3	1	0	0	1

0.0	0.0	0.0

COST CARDS

443797.	2541796.	1148573.	1874548.	3749095.	6.91	5.82	175000.
542621.	3104010.	1861539.	3201121.	4194177.	6.43	3.04	350000.
708844.	5150000.	3733945.	7588021.	6138587.	5.67	2.69	1050000.

MINERAL RESERVE DATA

0.02530	0.0	512015.00000

DISCOUNT RATES

SUPPLY PRICE OF CAPITAL IN MINING	0.068600000
OPPORTUNITY COST OF CAPITAL	0.014500000
BANK LENDING RATE	0.038000000
SOCIAL DISCOUNT RATE	0.022300000

NUMBER OF ITERATIONS 317

DETAILED DATA FOR OPTIMUM RETURN

PRODUCTION DATA

	TONS OF ORE	AVERAGE GRADE	CUTOFF GRADE	PRIMARY METAL IN CONCEN(LBS)	CONCENTRATE VALUE($)
1	0.0	0.0 %	0.0 %	0.0	0.0
2	0.0	0.0 %	0.0 %	0.0	0.0
3	53088.00000	4.09678%	1.56678%	4077375.15684	1965702.56311
4	53088.00000	4.09678%	1.56678%	4077375.15684	1965702.56311
5	53088.00000	4.09678%	1.56678%	4077375.15684	1965702.56311
6	53088.00000	4.09678%	1.56678%	4077375.15684	1965702.56311
7	53088.00000	4.09678%	1.56678%	4077375.15684	1965702.56311
8	49484.86529	1.95113%	1.22963%	1747875.31332	842650.68855

PRIMARY ORE PRODUCTION 275633.8TONS

TOTAL ORE PRODUCTION 314924.9TONS

ECONOMIC SUMMARY

EXPLORATION COSTS	265488.70896
PREPRODUCTION DEVELOPMENT COSTS	2199739.64695
MINING INVESTMENT	891387.57029
PROCESSING INVESTMENT	0.0
SOCIAL CAPITAL INVESTMENT	1699456.02871
PREPRODUCTION WORKING CAPITAL	505607.19549
GROSS CAPITAL COSTS	5561679.15039

MINING COSTS PER TON	7.73028
PROCESS COSTS PER TON	1.34600
ADMINISTRATIVE COSTS PER TON	1.36144
TOTAL	10.43772

DEBT-EQUITY RATIO	0.0
EQUITY CAPITAL	5561679.15039
BORROWED CAPITAL	0.0

	PRIMARY ORE	TOTAL ORE
PRESENT VALUE-#1 PROJECT INVESTMENT	-907967.01	-899432.71
-#2 EQUITY CAPITAL	-907967.01	-899432.71
-#3 GROSS SURPLUS	1610624.41	1653631.99
-#4 ECONOMIC RENT	-143178.73	-121547.78
-#5 NET SURPLUS	205613.95	248621.52
-#6 GROSS ROYALTY/TAX	2011237.89	2034457.89
-#7 NET ROYALTY/TAX	606227.42	629447.43

OPTIMIZING DONE ON # 1

#1,#2,AND #4 ARE DISCOUNTED AT THE SUPPLY PRICE OF PRIVATE CAPITAL.

#3,#5,#6,AND #7 ARE DISCOUNTED AT THE SOCIAL OPPORTUNITY COST.

FINAL YEAR FRACTION(PRIMARY ORE)	0.192
FINAL YEAR FRACTION(TOTAL ORE)	0.932

NET CAPITAL INVESTMENT

	PREPRODUCTION EXPLORATION	PREPRODUCTION DEVELOPMENT	MINING INVESTMENT	PROCESSING INVESTMENT	SOCIAL CAPITAL INVESTMENT	WORKING CAP. AND SALVAGE VAL	TOTAL CAPITAL
1	61062.40	898593.65	345256.69	0.0	658241.81	0.0	1963154.55
2	57876.54	754400.71	289212.93	0.0	551392.76	505607.20	2158490.13
3	0.0	0.0	22284.69	0.0	33989.12	758410.79	814684.60
4	0.0	0.0	22284.69	0.0	33989.12	0.0	56273.81
5	0.0	0.0	22284.69	0.0	33989.12	0.0	56273.81
6	0.0	0.0	22284.69	0.0	33989.12	0.0	56273.81
7	0.0	0.0	22284.69	0.0	33989.12	0.0	56273.81
8	0.0	0.0	4280.47	0.0	6528.67	0.0	10809.14

ROYALTY MINIMIZATION

	PROFIT AFTER EXPLOR	ANNUAL DEPRECIATION	PROCESSING ALLOWANCE	ROYALTY PROFIT	PROFIT BASE (18%)	BASIC ROYALTY	INCREMENTAL ROYALTY	TOTAL ROYALTY
1	0.0	505607.19549	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	910092.95188	0.0	0.0	364037.18075	0.0	0.0	0.0
3	1411584.63546	739329.12347	0.0	672255.51199	655266.92535	98290.03880	5946.00532	104236.04413
4	1411584.63546	602718.06074	0.0	808866.57472	532316.96890	79847.54533	96792.36204	176639.90737
5	1411584.63546	493429.21056	0.0	918155.42490	433957.00374	65093.55056	169469.44741	234562.99797
6	1411584.63546	405998.13042	0.0	1005586.50505	355269.03160	53290.35474	227611.11571	280901.47045
7	1411584.63546	336053.26630	0.0	1075531.36917	292318.65390	43847.79808	274124.45034	317972.24843
8	326141.28893	271004.44184	0.0	55136.84709	241958.35173	36293.75276	-65387.52663	-29093.77387

	YEARLY GROSS INVEST	MINING AND SERVICE INVEST	CUMULATIVE PROCESS INVEST	ANNUAL DEPREC RATE	ANNUAL DEPRECIATION	TOTAL UNDEPREC BALANCE	MINE AND SERVICE UNDEPREC BALANCE	INFLATED UNDEPREC BALANC
1	2528035.97745	2528035.97745	0.0	0.200000000000	505607.19549	2022428.78196	2022428.78196	2022428.78196
2	2528035.97745	2528035.97745	0.0	0.200000000000	910092.95188	3640371.80753	3640371.80753	3640371.80753
3	56273.80983	56273.80983	0.0	0.200000000000	739329.12347	2957316.49389	2957316.49389	2957316.49389
4	56273.80983	56273.80983	0.0	0.200000000000	602718.06074	2410872.24297	2410872.24297	2410872.24297
5	56273.80983	56273.80983	0.0	0.200000000000	493429.21056	1973716.84224	1973716.84224	1973716.84224
6	56273.80983	56273.80983	0.0	0.200000000000	405998.13042	1623992.52166	1623992.52166	1623992.52166
7	56273.80983	56273.80983	0.0	0.200000000000	336053.26630	1344213.06519	1344213.06519	1344213.06519
8	10809.14401	10809.14401	0.0	0.200000000000	271004.44184	1084017.76736	1084017.76736	1084017.76736

1 THE OPPORTUNITY COST OF CAPITAL IS 1.45%.

INCOME TAX CALCULATION 1977

	GROSS PROFIT AFTER CAPITAL TAX	ACCELERATED CAPITAL COST ALLOWANCE	NORMAL CAPITAL COST ALLOWANCE	RESOURCE ALLOWANCE	INTEREST ON LONG TERM DEBT	EXPLORATION DEDUCTION	PREPROD-DEVELOP ALLOWANCE	DEPLETION ALLOWANCE
1	0.0	369195.21286	0.0	0.0	0.0	132744.35448	329960.94704	0.0
2	0.0	627631.86186	0.0	0.0	0.0	132744.35448	560933.60997	0.0
3	1411584.63546	871164.45654	16882.14295	130884.50899	0.0	0.0	392653.52698	0.0
4	1411584.63546	593309.88779	28699.64301	197393.77616	0.0	0.0	274857.46889	79330.96490
5	1411584.63546	0.0	36971.89306	343653.18560	0.0	0.0	192400.22822	209639.83215
6	1411584.63546	0.0	42762.46809	342205.54184	0.0	0.0	134680.15975	222984.11644
7	1411584.63546	0.0	46815.87061	341192.19121	0.0	0.0	94276.11183	232325.11545
8	326141.28893	0.0	33569.55708	73142.93296	0.0	0.0	65993.27828	38358.88015

	TAXABLE PROFIT(LOSS) AFTER PRIOR LOSSES	INCOME TAX	UNDEP-BALANCE ACCEL-CCA	UNDEP-BALANCE NORMAL CCA	UNAMORTIZED DEBT	CUMULATIVE EXPLORATION	UNDEP-BALANCE PREPRO-DEVELOP	UNDEP-BALANCE DEPLETION
1	0.0	0.0	861455.49667	0.0	0.0	0.0	769908.87643	842678.65915
2	0.0	0.0	1464474.34433	0.0	0.0	0.0	1308845.08993	1685357.31830
3	0.0	0.0	593309.88779	39391.66688	0.0	0.0	916191.56295	1685357.31830
4	237992.89471	121376.37630	0.0	66965.83370	0.0	0.0	641334.09407	1606026.35340
5	628919.49644	320748.94318	0.0	86267.75047	0.0	0.0	448933.86585	1396386.52125
6	668952.34933	341165.69816	0.0	99779.09221	0.0	0.0	314253.70609	1173402.40481
7	696975.34636	355457.42664	0.0	109237.03143	0.0	0.0	219977.59427	941077.28936
8	115076.64045	58689.08663	0.0	86476.61836	0.0	0.0	153984.31599	902718.40920

TOTAL TAX CREDITS AMOUNTED TO 129542.17995 $.
CREDITS USED AMOUNTED TO 129542.17995 $.

PRESENT VALUE CALCULATIONS

#1 PROJECT CASH FLOW

	OPERATING PROFIT	CAPITAL TAX	INCOME TAX	MINING ROYALTY	TOTAL INVESTMENT	WORKING CAPITAL AND SALVAGE VALUE	CASH FLOW
1	0.0	0.0	0.0	0.0	1963154.54582	0.0	-1963154.54582
2	0.0	0.0	0.0	0.0	1652882.93328	505607.19549	-2158490.12877
3	1411584.63546	0.0	0.0	104236.04413	56273.80983	758410.79323	492663.98827
4	1411584.63546	0.0	121376.37630	176639.90737	56273.80983	0.0	1057294.54196
5	1411584.63546	0.0	320748.94318	234562.99797	56273.80983	0.0	799998.88448
6	1411584.63546	0.0	341165.69816	280901.47045	56273.80983	0.0	733243.65703
7	1411584.63546	0.0	355457.42664	317972.24843	56273.80983	0.0	681881.15056
8	326141.28893	0.0	58689.08663	-29093.77387	10809.14401	0.0	285736.83216

PRESENT VALUE IS -899432.71

1 THE SUPPLY PRICE OF PRIVATE CAPITAL IS 6.86%.

#2 EQUITY CASH FLOW

	PROJECT CASH FLOW	BORROWED CAPITAL	DEBT REPAYMENT	INTEREST ON DEBT	CASH FLOW
1	-1963154.54582	0.0	0.0	0.0	-1963154.54582
2	-2158490.12877	0.0	0.0	0.0	-2158490.12877
3	492663.98827	0.0	0.0	0.0	492663.98827
4	1057294.54196	0.0	0.0	0.0	1057294.54196
5	799998.88448	0.0	0.0	0.0	799998.88448
6	733243.65703	0.0	0.0	0.0	733243.65703
7	681881.15056	0.0	0.0	0.0	681881.15056
8	285736.83216	0.0	0.0	0.0	285736.83216

PRESENT VALUE IS -899432.71

1 EQUITY CASH FLOW IS THAT AFTER ADDING BORROWED CAPITAL AND SUBTRACTING DEBT REPAYMENT AND INTEREST.

2 THE BANK LENDING RATE IS 3.80%.

3 THE SUPPLY PRICE OF PRIVATE CAPITAL IS 6.86%.

#3 GROSS SURPLUS

	PROJECT CASH FLOW	CAPITAL TAX	INCOME TAX	MINING ROYALTY	CASH FLOW
1	-1963154.54582	0.0	0.0	0.0	-1963154.54582
2	-2158490.12877	0.0	0.0	0.0	-2158490.12877
3	492663.98827	0.0	0.0	104236.04413	596900.03240
4	1057294.54196	0.0	121376.37630	176639.90737	1355310.82563
5	799998.88448	0.0	320748.94318	234562.99797	1355310.82563
6	733243.65703	0.0	341165.69816	280901.47045	1355310.82563
7	681881.15056	0.0	355457.42664	317972.24843	1355310.82563
8	285736.83216	0.0	58689.08663	-29093.77387	315332.14492

PRESENT VALUE IS 1653631.99

1 PUBLIC CASH FLOW1 ASSUMES THAT THE PROJECT WOULD NOT HAVE BEEN UNDERTAKEN BY A PRIVATE COMPANY SO THAT TAXES AND ROYALTIES ARE NOT A COST TO THE PROJECT.

2 THE DISCOUNT RATE USED IS 2.23%(THE SOCIAL OPPORTUNITY COST).

#4 ECONOMIC RENT

	PROJECT CASH FLOW	ROYALTY PAYMENTS	CASH FLOW
1	-1963154.54582	0.0	-1963154.54582
2	-2158490.12877	0.0	-2158490.12877
3	492663.98827	104236.04413	596900.03240
4	1057294.54196	176639.90737	1233934.44933
5	799998.88448	234562.99797	1034561.88245
6	733243.65703	280901.47045	1014145.12747
7	681881.15056	317972.24843	999853.39899
8	285736.83216	-29093.77387	256643.05829

PRESENT VALUE IS -121547.78

1 ECONOMIC RENT IS THE PRESENT VALUE OF THE PROJECT EXCLUSIVE OF ANY ROYALTIES.

2 THE SUPPLY PRICE OF PRIVATE CAPITAL IS 6.86%.

#5 NET SURPLUS

	GROSS SURPLUS	FOREGONE TAXES AND ROYALTIES	REMAINING SURPLUS
1	-1963154.54582	564881.43163	-2528035.97745
2	-2158490.12877	875153.04417	-3033643.17294
3	596900.03240	0.0	596900.03240
4	1355310.82563	0.0	1355310.82563
5	1355310.82563	0.0	1355310.82563
6	1355310.82563	0.0	1355310.82563
7	1355310.82563	0.0	1355310.82563
8	315332.14492	0.0	315332.14492

PRESENT VALUE IS 248621.52

#6 GROSS TAXES AND ROYALTIES

	PROVINCIAL ROYALTIES	CAPITAL TAX	INCOME TAXES	TOTAL TAXES AND ROYALTIES
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0
3	104236.04413	0.0	0.0	104236.04413
4	176639.90737	0.0	121376.37630	298016.28367
5	234562.99797	0.0	320748.94318	555311.94115
6	280901.47045	0.0	341165.69816	622067.16861
7	317972.24843	0.0	355457.42664	673429.67507
8	-29093.77387	0.0	58689.08663	29595.31277

PRESENT VALUE IS 2034457.89

#7 NET TAXES AND ROYALTIES

	TOTAL TAXES AND ROYALTIES	FOREGONE TAXES AND ROYALTIES	REMAINING TAXES AND ROYALTIES
1	0.0	564881.43163	-564881.43163
2	0.0	875153.04417	-875153.04417
3	104236.04413	0.0	104236.04413
4	298016.28367	0.0	298016.28367
5	555311.94115	0.0	555311.94115
6	622067.16861	0.0	622067.16861
7	673429.67507	0.0	673429.67507
8	29595.31277	0.0	29595.31277

PRESENT VALUE IS 629447.43

Chapter 3

Data Used for the Analysis

The data required for the analysis is divided into three major categories. These are: (i) capital and operating costs; (ii) mineral deposits, and; (iii) other. The latter consists of discount rates, inflation rates, and net smelter returns. In order that the results of the analysis reflect the mining conditions appropriate for the province of Manitoba, the cost and mineral reserve data are representative of those in Manitoba. The discount rates, inflation rates, and net smelter returns, while relevant to Manitoba, are national averages. Costs, prices, and inflation rates are determined for the years 1969 and 1977. The real discount rates are assumed to remain constant over time.

3.1 Capital and Operating Cost Data

Capital and operating costs for typical mine-concentrator projects in Northern Manitoba were estimated in a separate study[1] carried out in the Department of Mines, Resources and Environmental Management. The study provided estimates for three different sizes of copper-zinc project. This is sufficient information to enable the model to generate the required continuous cost-size functions.

The capital costs are subdivided into five categories appropriate for calculating income taxes. These are:

(i) preproduction exploration;

(ii) preproduction development;

(iii) mine assets;

[1]Goldstone, A., Capital Expenditure Analysis, Study financed jointly by the Federal and Provincial governments under a DREE agreement (project number 6-77-2).

(iv) concentrator (or processing) assets;

(v) social and service assets.

Preproduction exploration costs are those necessary to delineate a deposit so that some estimate of total mineral content can be made. It includes both drilling and exploratory shaft sinking if necessary. It does not include the exploration costs incurred prior to the discovery of the deposit.

Preproduction development costs are for shaft sinking and stope development prior to production and any temporary surface facilities such as access roads. The development costs used in this analysis are reduced to two-thirds of those shown in the Goldstone study because in that study it was assumed that all preproduction costs would be incurred prior to production. In practice stope development is carried out continuously as production takes place. The remaining development costs incurred constitute part of the mine operating costs.

Mine asset costs include those for the headframe and building, ventilation equipment, underground crushers, underground transportation facilities and drilling equipment. Installation costs are included.

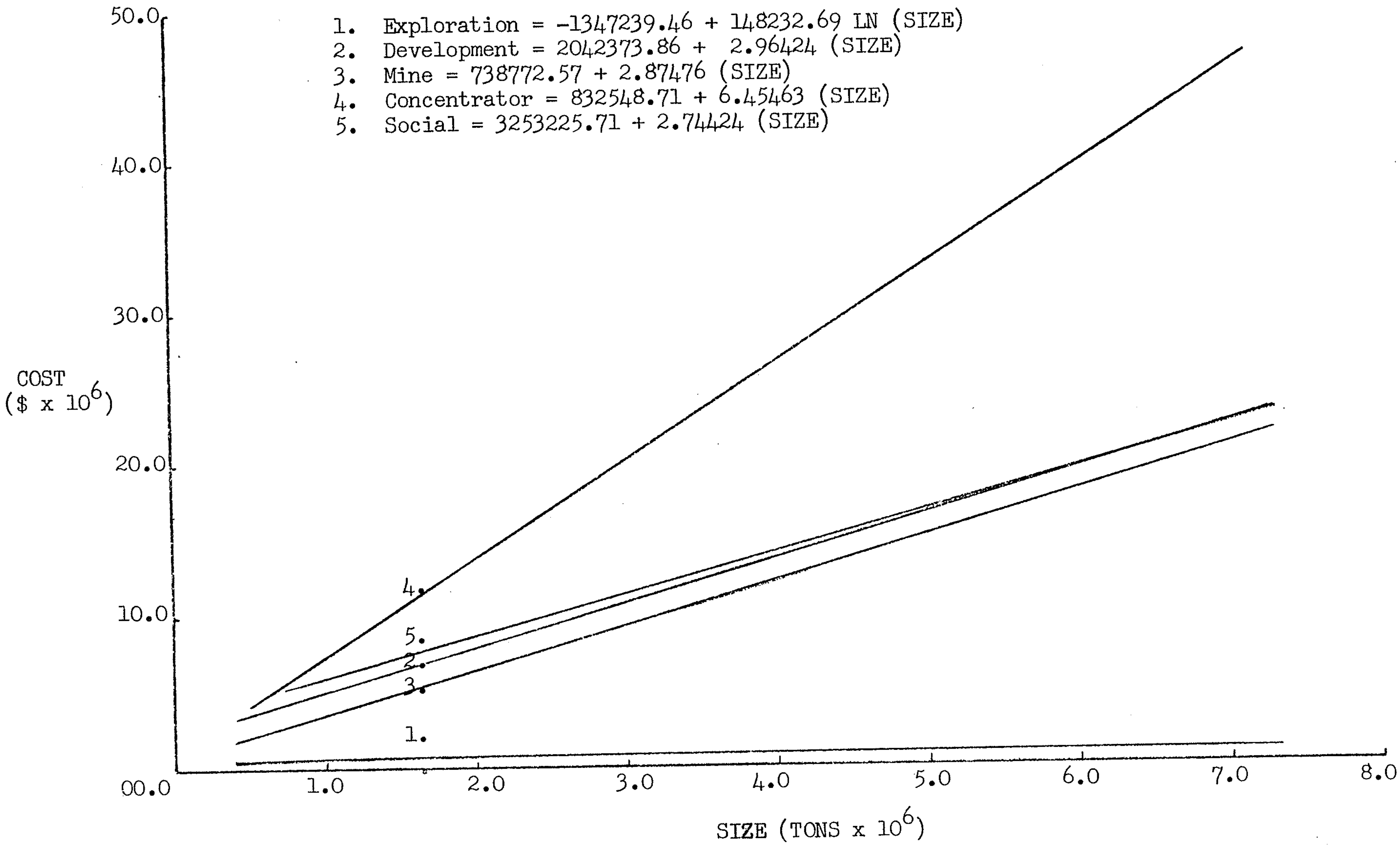
Mill assets include surface crushers, ball and rod mills, floatation circuits, storage facilities, and the concentrator building. Again, the costs of these assets include installation charges.

Service and social assets include permanent roads, power facilities, and any on-site service buildings and equipment.

The capital cost estimates for 1969 are shown in Table 3.1 and the curves generated by the computer model from the data are shown in Figure 3.1. The capacity for each size of facility is measured in tons of ore processed per year (TPY). For the smaller two of the three projects evaluated in the analysis, these costs are modified in the computer program

Figure 3.1

1969 CAPITAL COST CURVES



to reflect the assumption that they are undertaken by a nearby mining company earning other income. Exploration and development costs to the company are reduced by the income taxes and, where appropriate, royalties that are saved as a consequence of these costs being recoverable from other income. Service asset costs are assumed to be one-half the value that would be calculated for a separate project, reflecting the fact that some roads and service assets would already be available to a new project because of development by the existing mine. Finally, for the smallest size of project, the mill asset costs are reduced to zero on the assumption that a separate facility would not have to be constructed to process the ore mined.

Table 3.1

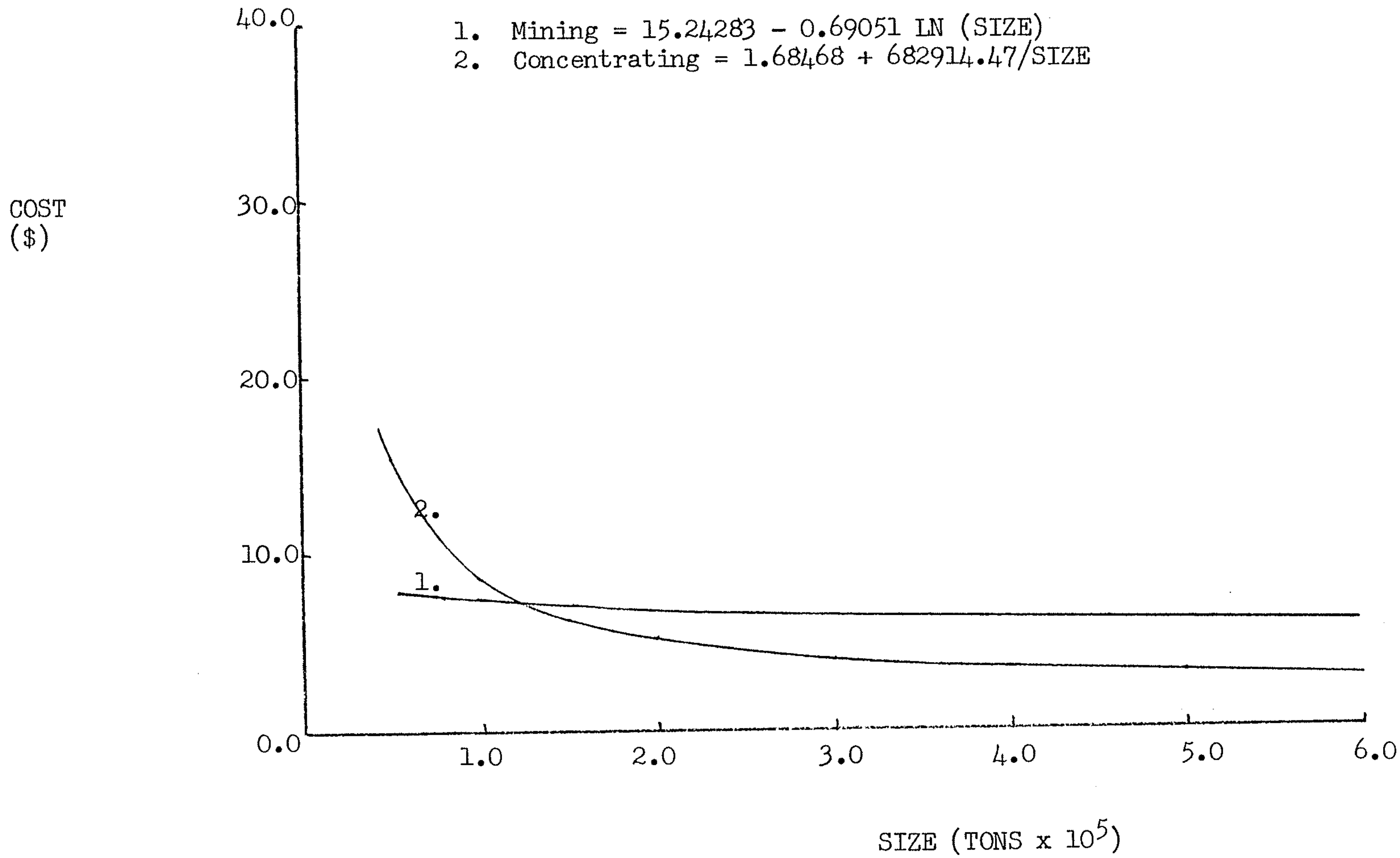
1969 Capital Cost Estimates

	175,000 TPY	350,000 TPY	1,050,000 TPY
Exploration	$443,797.	542,621.	708,844.
Development	2,541,796.	3,104,010.	5,150,000.
Mine Assets	1,148,573.	1,861,539.	3,733,945.
Mill Assets	1,856,989.	3,201,121.	7,588,021.
Service Assets	3,749,095.	4,194,177.	6,138,587.

The capital costs for 1977 are those for 1969 inflated by a factor of 1.86797. This factor (derived later in section 3.3) adjusts all costs for the inflation that has occurred from 1969 to 1977. The 1977 costs derived are shown in Table 3.2. The operating cost data for 1969 and 1977 are shown in Table 3.3. The curves generated by the program from the 1969 data are shown in Figure 3.2. As was the case with the capital costs, the 1977 values are those for 1969 times a factor of 1.86797. The same factor

Figure 3.2

1969 OPERATING COST CURVES



is used for both capital and operating costs on the assumption that the most important elements of operating costs (labour and energy) are increasing at the same general rate as the most important costs associated with the production of mining capital assets (also labour and energy). For the smallest of the three projects, which does not have a separate concentrator, the computer model automatically assigns a constant milling cost of 0.5 times the milling cost for the 1,050,000 ton per year facility as provided in the input data. This is the assumed cost to the firm which would use its existing concentrator.

Table 3.2

1977 Capital Cost Estimates

	175,000 TPY	350,000 TPY	1,050,000 TPY
Exploration	$829,000.	1,013,600.	1,324,000.
Development	4,740,000.	5,798,199.	9,620,048.
Mine Assets	2,145,501.	3,477,300.	6,974,899.
Mill Assets	3,468,801.	5,979,600.	14,174,200.
Service Assets	7,003,200.	7,834,599.	11,466,700.

Table 3.3

Operating Cost Estimates

	175,000 TPY	350,000 TPY	1,050,000 TPY
1969 - Mine	$6.906	6.429	5.669
- Mill	5.825	3.041	2.692
1977 - Mine	12.90	12.01	10.59
- Mill	10.88	5.68	5.03

Overhead and administrative costs for each project are 15 percent of the mine plus mill operating costs. This value is also calculated automatically in the computer program.

3.2 Mineral Deposit Data

Three representative sized deposits are used in the analysis. Each is the mean of the deposits in three ranges of deposit size which are producing or have produced in the province. The three ranges are 100 thousand to 1 million tons, 1 million to 10 million tons, and 10 million to 100 million tons. The deposits are listed in Table 3.4. The quantity of ore for each deposit is as reported in mining company annual reports. It is the sum of ore that has been mined plus known ore reserves.

The average quantity of ore and the average grades of the metal in the ore for the three representative deposits are shown in Table 3.5. However it must be remembered that "ore" is only that mineral which can be economically recovered from a deposit so that the total mineral content of a deposit will normally be significantly greater. To extrapolate beyond known ore in a deposit requires, first, some general knowledge of the relationship between the tonnage of material versus its average grade, and second, the economic conditions which defined the cut-off grade for the deposit. Using estimates for each, plus the information in Table 3.5, the representative mineral deposits determined[2] for this study are as shown in Table 3.6. The average grade is for the copper alone. Zinc, silver, and gold are by-products whose value is reflected in the net smelter return appropriate for each deposit.

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[2] The representative deposits are derived in Appendix I.

Table 3.4

Production plus Ore Reserves for Copper-Zinc Mines

That Have Produced or are Producing in Manitoba[1]

Property Name	Size (Tons)	Cu (%)	Zn (%)	Average Grades[2] Ag (oz/ton)	Au (oz/ton)
Mandy	150,021	7.89	16.5	1.90	0.095
North Star	275,962	6.121	-	0.26	0.011
Ghost	283,800	1.835	12.73	1.12	0.024
White	425,200	2.244	4.826	0.97	0.017
Cuprus	509,374	3.25	6.4	0.84	0.038
Dickstone	1,077,642	2.436	3.50	0.29	0.009
Centennial	1,460,000	2.06	2.60	0.70	0.04
Schist	2,070,356	4.21	7.0	0.72	0.026
Anderson	3,062,300	3.854	0.10	0.18	0.012
Osborne	3,351,380	3.70	1.512	0.20	0.01
Stall	5,353,492	4.672	0.652	0.25	0.033
Chisel	5,952,215	0.522	11.66	1.22	0.047
Sherridon	8,531,352	2.375	1.487	0.559	0.0186
Fox	14,003,000	2.034	1.926	0.30[3]	0.01[3]
Ruttan	43,278,294	1.553	1.414	0.20[3]	0.01[3]
Flin Flon	64,127,657	2.319	4.287	0.56	0.05

Notes:
1. Main sources are, Open File Report 77/1, NREP First Annual Report (Dept. of Mines, Resources and Environmental Management) and Bamburak, J. D., Open File Report 77/2, Important Mineral Properties of Manitoba (Dept. of Mines, Resources and Environmental Management).
2. In most cases, the gold and silver values are for the remaining reserves as of January 1, 1974.
3. These are estimates only.

Table 3.5

Quantity of Ore and Grades for Each Size of Deposit

Deposit	Size (tons)	Cu (%)	Zn (%)	Ag (oz/ton)	Au (oz/ton)
#1	328,871	3.65	6.93	.921	.031
#2	3,857,342	2.82	3.66	.634	.021
#3	40,469,650	2.01	2.99	.402	.031

Table 3.6

Total Mineral Tonnage Per Deposit

Deposit	Total Mineral (tons)	Average Grade Cu (%)
#1	512,015	2.53
#2	7,920,787	1.64
#3	89,015,324	1.12

The grade-tonnage functions for each of the deposits are depicted in Figures 3.3, 3.4, and 3.5. Note that each function is log-linear and that the total tonnage for the deposit is determined at a cut-off grade of 0.0%. That is, where the cut-off grade function crosses the horizontal axis determines the total mineral content of the deposit as shown in Table 3.6. The equations were determined by the computer model.

3.3 Other Data

The remaining data necessary to carry out an experiment are the discount rates, inflation rates, and the net smelter return for each deposit as of 1969 and 1977.

Figure 3.3

MINERAL RESERVE FUNCTIONS

DEPOSIT #1

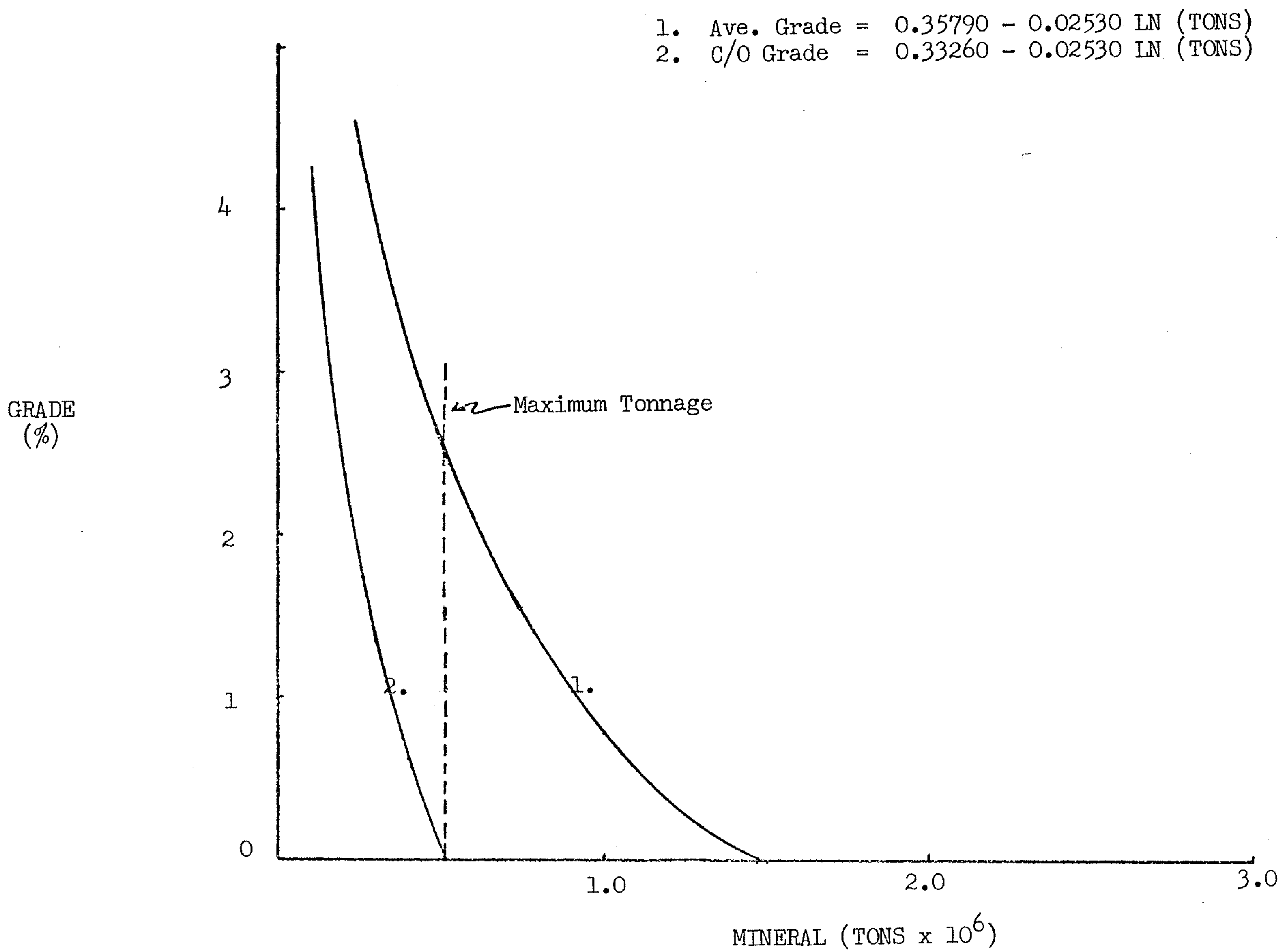


Figure 3.4

MINERAL RESERVE FUNCTIONS

DEPOSIT #2

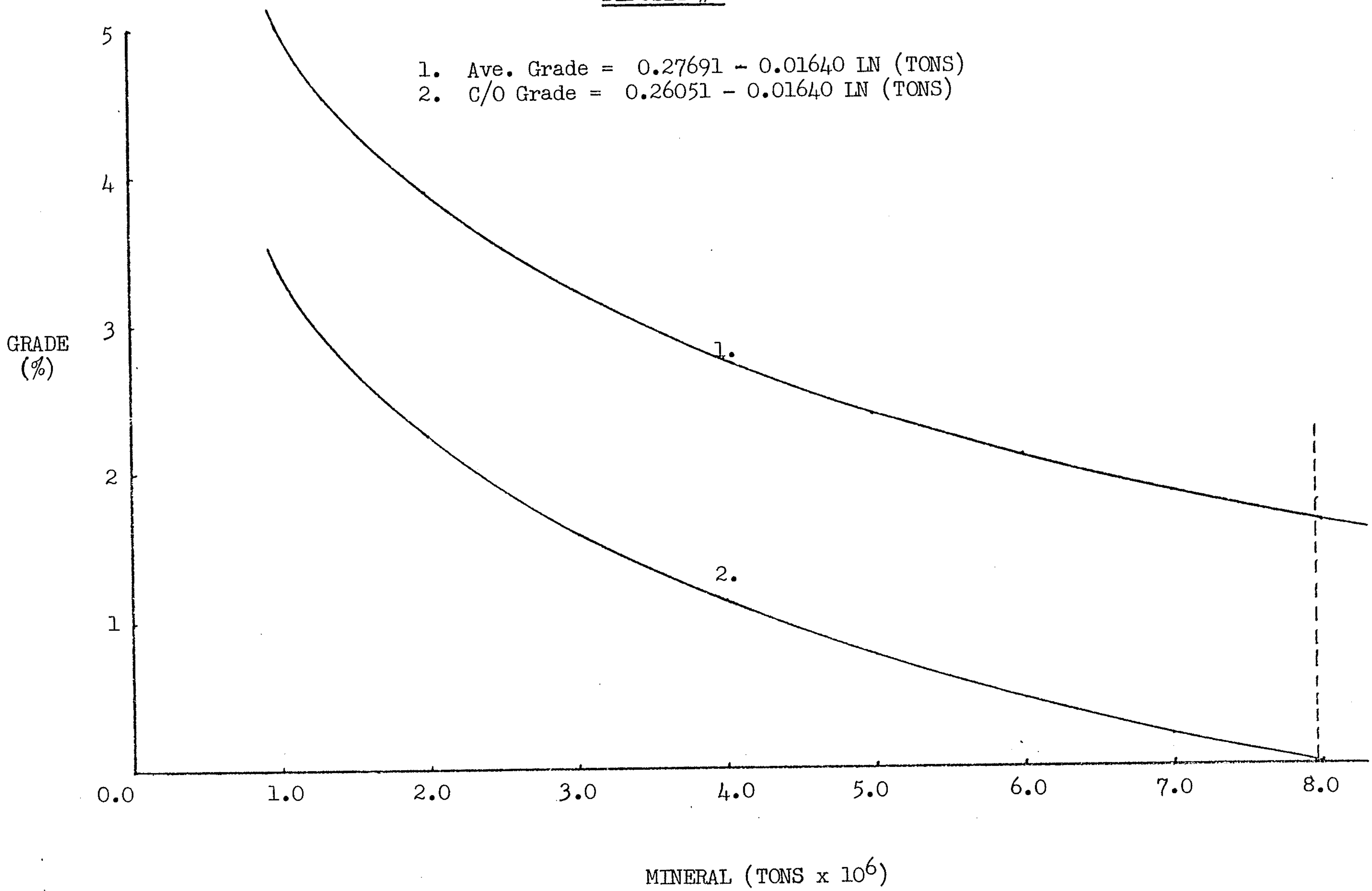
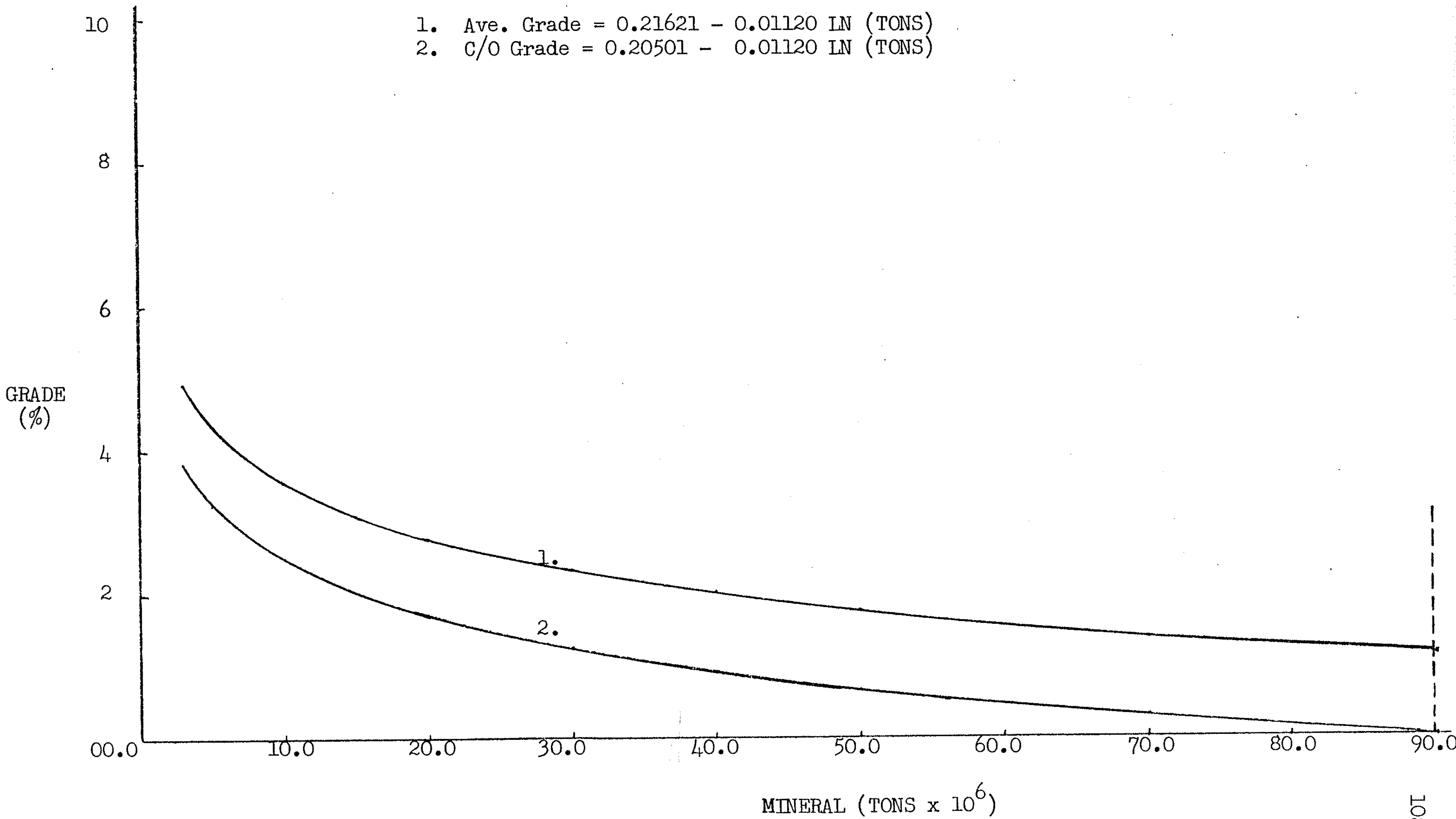


Figure 3.5

MINERAL RESERVE FUNCTIONS

DEPOSIT #3



Discount Rates

Four different discount rates are provided in the input data for any experiment. They are real rates but they will be modified in the computer program if inflation is greater than zero for any experiment as explained in Chapter 2. The rates are:

(i) The Supply Price of Capital (SPC)

(ii) The Private Opportunity Cost (POC)

(iii) The Bank Lending Rate

(iv) The Social Opportunity Cost (SOC)

Had any of the benefits from the project been non-monetary in form, they could be shadow-priced in the manner suggested by Mishan and discounted at the social time preference rate.[3] This would introduce a fifth possible discount rate which at present cannot be utilized in the computer model.

The real supply price of private capital is the minimum return a private firm could expect before it would invest in a mining venture. It will be the opportunity cost of that capital plus an additional amount that will constitute a risk premium because of the uncertainty about future costs, revenues, and ore quality. The size of both the risk premium and the opportunity cost can be expected to vary according to the nature of the market a firm sells in and the characteristics of the company's ore reserves. A large firm that can exercise some market control or sells a diverse range of products will face less uncertainty than a small firm which sells a single commodity in an open market. Similarly, a large firm which can produce from any of a number of possible ore bodies faces less risk than a small firm which may only have one producing ore body. On the other hand,

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[3] Mishan, E. J., Cost Benefit Analysis (London: George Allen & Unwin Ltd., 1971), Chapter 32.

a large firm which can operate in a relatively monopolistic manner because of its market power, its control of sources of ore, and its ownership of technology will have a higher than normal opportunity cost reflecting its greater profit making opportunities. As a result, the supply price of capital for a large firm may not be significantly different from that of a small firm.

The actual value of the supply price of capital used by mining firms has been observed to range anywhere from 12 percent to 20 percent (including inflation) with the most common value being in the region of 15 percent.[4] In order that the minimum acceptable return will reflect changing bank lending rates and the effects of inflation, a discount rate of twice the prime interest rate is often used. Employing this method for the period from 1969 to 1977, the discount rate ranged from 9 to 19 percent. Abstracting from inflation, it varied from less than 1 percent to nearly 15 percent. The value used for this study is the mean of the above real rates or 6.86 percent.[5] Including 1969 and 1977 inflation this produces rates of nearly 12 percent and just over 16 percent respectively which are consistent with the values usually employed in feasibility studies. The real rate is assumed to be the same for the life of projects evaluated in 1969 and 1977. As discussed above, the rate should not be overly sensitive to the assumption about the kind of firm undertaking the projects, so the same rate is applied to the three sizes of project.

The second discount rate required for the analysis is the private opportunity cost. It is defined as the best (risk-free) return capital could

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[4]The Mining Association of Canada carried out a series of tax and royalty studies which compared the tax regimes of a number of provinces. A rate of return of 15 percent was described as "approaching acceptable levels", Mining Association of Canada, MAC Task Force Mine Model Analysis, Manitoba, (Toronto, 1978), p. 4.

[5]See Appendix II.

earn in an alternate investment. Its actual use in the study is limited to the 1977 royalty system where the subroutine calculating the anticipated royalties will do so in a manner which will minimize the present value the annual royalty assessments. The value for this rate has been estimated by subtracting from the supply price of capital, an amount which would represent the premium for the anticipated risk and uncertainty. The former value has already been estimated to be 6.86 percent. An estimate for the latter value is obtained by calculating the standard deviation of net income to share-holders equity for the province's major copper-zinc firm over a period of years. This value was determined to be 5.33 percent.[6] Let Q be the element of uncertainty in the return to equity, SPC is the real supply price of capital, and POC is the real opportunity cost. Q will have a value such that when used in a discount factor, $1/(1+SPC) = 1/(1+Q)(1+POC)$ or $(1+SPC) = (1+Q)(1+POC)$. Solving for POC,

$$\begin{aligned} POC &= (1+SPC)/(1+Q) - 1 \\ &= (1+.0686)/(1+.0533) - 1 \\ &= .0145 \end{aligned}$$

It is assumed that this rate will remain constant from 1969 to 1977 as well.

The third discount rate is the real bank lending rate. This is the interest rate on borrowed capital which would be used to finance mine projects. Because it is assumed that equity capital is used for the projects in this study, a value is not needed. However some figure must be included in the input data to the program even if it is not used. A value for the lending rate was estimated by averaging the real rate paid by the mining companies in the province on the bonds and debentures issued. From 1968 to

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[6] Rugman, A., Risk and Return in the Canadian Mineral Resource Industry, (Kingston: Centre for Resource Studies, Queen's University, 1976).

1975 the real rate averaged 3.80 percent.[7] Note that it is well below the supply price of capital but above the private opportunity cost.

The final discount rate used in the study is the social opportunity cost. This rate is the average pre-tax rate of return capital can earn in the province. Like the private opportunity cost already estimated, the social opportunity cost will not contain a premium for risk and uncertainty. The effective income tax rate, R, in Canada from 1969 to 1977 averaged 35 percent for all industries.[8] Assuming the reduction in the rate of return to an investment because of taxes is equal to the effective tax rate, the private opportunity cost POC will equal (1 - R) times the social opportunity cost SOC. That is POC = (1 - R) SOC and

$$SOC = POC/(1 - R) = .0145/(1 - 0.35) = 0.0223$$

As with the previous discount rates, this is a real rate and is assumed to remain constant over time.

To summarize, the estimated values for the four discount rates are as follows:

Table 3.7

Discount Rate Estimates

Supply Price of Capital	Private Opportunity Cost	Bank Lending Rate	Social Opportunity Cost
0.0686	0.0145	0.0380	0.0223

[7] See Appendix III.

[8] From Appendix I to Chapter 1.

The two most important rates are the supply price of capital and the social opportunity cost since they are the discount rates used in the present value calculations. However all the rates could simultaneously be increased or decreased significantly without affecting the results of the analysis in a material way. For example, the percent decrease in the value of a mining project from 1969 to 1977 because of the increased income tax assessments would not change appreciably if the supply price of capital were, say, increased by 20 percent. This is because the same discount rate is used regardless of the legislation in effect. The one factor which could have a significant bearing on the results is the difference between the supply price of capital and the social opportunity cost. This is important for that part of the analysis which is concerned with the legislation from the province's point of view. Simply increasing the discount rate above the socially optimum rate will change the characteristics of the project whose profit stream (present valued) is being maximized. Thus the greater the difference in the discount rates used, the greater will be the differences in the characteristics of the resulting project.

Inflation Rates

The two inflation rates used in the analysis are for the years 1969 and 1977. They are calculated from data provided in Statistics Canada 13-211, Fixed Capital Flows and Stocks: Mining (including milling), Quarries, and Oil Wells. Using the figures for Gross Fixed Capital Formation (GFCF) which, for each year, are expressed in current dollars and 1961 dollars, an index base 1961 is calculated. Dividing the current year's index by the previous year's index gives the current year's inflation factor. Subtracting 1 from this gives the inflation rate for the year. The results are summarized in Table 3.8.

Table 3.8

Inflation Rates

Year	GFCF 1961 $ x 10^6	GFCF Current $ x 10^6	Index (Base 1961)	Inflation Factor	Inflation Rate (x 100)
1968	883.7	1074.1	1.215458	-	-
1969	924.4	1177.2	1.273475	1.04773	4.773
1976	1585.4	3447.7	2.174656	-	-
1977	1734.1	4125.1	2.378813	1.09388	9.388

In order to make comparisons of value between the years 1969 and 1977, the 1977 results are expressed in 1969 dollars. The inflation factor used for this is determined by dividing the 1977 Index (Base 1961) by the 1969 Index (Base 1961). The factor is 2.378813/1.273475 = 1.86797. That is, in a period of eight years, costs have increased by about 87 percent.

Net Smelter Returns

The net smelter return per pound of copper in concentrate is shown in Table 3.9.[9] The figures reflect the value of by-products which are also recoverable. The unique value for each deposit occurs because of the differing proportions of metals in the ore.

Table 3.9

Net Smelter Returns (NSR*)

Year	Deposit #1	Deposit #2	Deposit #3
1969	$ .4821	.4501	.4658
1977	.8196	.7285	.7611

[9] An example of how the NSR* for Deposit #1 in 1969 was calculated is contained in Appendix I.

Briefly, the NSR* is calculated as follows. The NSR for each metal is calculated by deducting from the refined metal price the contract costs of smelting, refining, and transportation. Allowance is made for the rate of recovery at the smelting and refining stage. The NSR for each metal is the same for all concentrate. The value for a ton of ore in concentrate is then calculated and used to derive a single NSR* per pound of copper in concentrate.

APPENDIX I

DERIVING THE REPRESENTATIVE MINERAL DEPOSITS

Manitoba metallic mineral deposits generally occur as some combination of massive sulphides and disseminated sulphides. A deposit may consist of a single zone (or pocket of mineralization) or a series of zones. It is not uncommon for a zone to consist entirely of ore. That is, all the mineralized material right to the boundary with the host rock can be profitably mined. Typically, a deposit will consist of a small quantity of relatively high grade mineral and larger quantities of lower grade material. Given a function expressing the relationship between the quantity of ore and the average grade, it can be used to estimate the total mineral content of each representative deposit.

One function which has been developed by Musgrove to express this relationship is exponential in form. It is:[1] $R(G) = Ae^{-G/K}$ where

A is the total tonnage of mineral in the deposit;

K is the average grade of the deposit;

G is a selected cut-off grade; and

R(G) is the amount of ore above the cut-off grade.

The average grade of the ore is $G_{ave}(G) = G+K$.

The cut-off grade G for any deposit is directly related to operating costs and inversely related to the net smelter return. Normally this grade will be different for each deposit and for a single deposit it will likely change over time. Using the mine and mill operating costs already determined for 1969, the average total operating costs for the project appropriate in size to develop each deposit are shown in Table 1.

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[1]Musgrove, P. A., "Mathematical Aspects of the Grade-Tonnage Distribution of Metals", Appendix to, Brooks, D. B., "Mineral Supply as a Stock", in Vogely, W. A., ed., Economics of the Mineral Industries, (New York: American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., 1976).

Table 1

Total Operating Costs

Project	Capacity (TPY)	Total Cost ($ per ton)
#1	100,000	$9.935
#2	750,000	9.771
#3	4,000,000	7.592

The net smelter return for each deposit is expressed in terms of the copper content in concentrate since this is the primary metal in the ore. Zinc, silver and gold are by-products. The net smelter return for each size of deposit as of 1969 is shown in Table 2. The method for arriving at each value is shown following the table.

Table 2

Net Smelter Return Calculations

Deposit	N.S.R. Cu	N.S.R. Zn	N.S.R. Ag	N.S.R. Au	Gross Value, Ore	Ore Grade, Cu	N.S.R.* Per lb. Cu
#1					$32.3794	.0365	0.4821
#2	$ .3678	.0606	1.6273	34.7962	23.3545	.0282	0.4501
#3					17.2263	.0201	0.4658

The net smelter return (N.S.R.*) is determined in two steps. The first step is to calculate the N.S.R. for each metal. The average 1969 metal prices as reported by Statistics Canada for purposes of valuing metal production are:

1969 metal prices are: Cu - $0.500/lb.

Zn - $0.151/lb.

Ag - $1.76875/oz.

Au - $37.822/oz.

Assumed smelter-refinery recovery rates are: Cu - 94.23%

Zn - 80.00%

Ag - 92.00%

Au - 92.00%

The smelter-refinery-transportation charges as reported in a feasibility study for a copper mine-concentrator project[2] in Manitoba, adjusted to 1969, are: Cu - $0.1097

Zn - $0.0752

Ag - 0.0

Au - 0.0

The N.S.R. per unit of metal in concentrate is:

Copper	($0.5000 - 0.1097)	x	.9423	=	$0.3678
Zinc	($0.1510 - 0.0752)	x	.8000	=	$0.0606
Silver	$1.76875	x	.92	=	$1.6273
Gold	$37.822	x	.92	=	$34.7962

After the N.S.R. for each metal is determined (it will be the same for all deposits), then the net smelter return for the principle metal in a deposit (N.S.R.*) can be derived. It will be unique for each deposit. Assume that the N.S.R.* for deposit number 1 is being calculated. The ore value per ton in the form of concentrate is found by summing the recoverable values for each metal:

Copper	.0365	x	.3678	x	.92	x	2000	=	$24.7014
Zinc	.0693	x	.0606	x	.75	x	2000	=	6.2994
Silver	.921	x	1.6273	x	.56			=	.8393
Gold	.031	x	34.7962	x	.50			=	.5393
					Total			=	$32.3794

[2]Watts, Griffis, and McQuat Limited, Feasibility Study for Cerro Corporation on the Pine Bay Mine, (Toronto: 1973).

The net smelter return per pound of copper in concentrate is found by dividing the value of the ton of ore in concentrate form by the number of pounds of copper in the concentrate:

$$N.S.R.^* = \$32.38/(2000 \times .92 \times .0365) = \$0.4821$$

With the N.S.R.* per pound of copper determined for each deposit and the operating costs known, the cut-off grades can be calculated. In each case, the cut-off grade G = Operating Cost/(N.S.R.* x 2000 x R.R.). Since (from Musgrove), $G_{ave}(G) = G+K$, then for each deposit $K = G_{ave}(G) - G$. Finally, rearrange the relationship $R(G) = Ae^{-G/K}$ so that $A = e^{G/K}R(G)$. The results are summarized in Table 3.

Table 3

Total Deposit Tonnage

Deposit	R(G) (tons)	$G_{ave}(G)$	G =	∴ K =	and A = (tons)
#1	328,871	.0365	.01120	.0253	512,015
#2	3,857,342	.0282	.01180	.0164	7,920,787
#3	40,469,650	.0201	.00886	.0112	89,015,324

An explicit assumption in this method of calculating the deposit size is that Zn, Ag, and Au grades vary proportionally to the Cu grade.

APPENDIX II

SUPPLY PRICE OF CAPITAL

Year	Prime Rate[1]	2x Prime Rate	Inflation Rate[3]	Supply Price of Capital[2]
1967	.0450	.090	.0274	.0609
1968	.0750	.150	.0023	.1474
1969	.0750	.150	.0477	.0976
1970	.0700	.140	.0423	.0937
1971	.0525	.105	.0458	.0566
1972	.0475	.095	.0908	.0039
1973	.0575	.115	.0753	.0369
1974	.0875	.175	.1252	.0443
1975	.0825	.165	.1057	.0536
1976	.0950	.190	.0734	.1086
1977	.0750	.150	.0939	.0513
			Average Value	.0686

Notes:

1. July 1 rate published by the Bank of Canada.
2. Real Supply Price = $\frac{(1 + 2x\text{ Prime Rate})}{(1 + \text{Inflation Rate})} - 1$
3. Inflation rates are calculated from Statistics Canada 13-211, Fixed Capital Flows and Stocks; Mining (including Milling), Quarries, Oil Wells.

APPENDIX III

BANK LENDING RATE

Long term debt for the Province's mining companies is provided by the issue of debentures or bonds. The following rates are quoted for the current long term debt of the companies.

YEAR	INTEREST RATE	INFLATION RATE	REAL RATE
1968	.0685	.0023	.0660
1970	.0925	.0423	.0482
1971	.0863	.0458	.0387
1971	.0900	.0458	.0423
1971	.0775	.0458	.0303
1971	.0885	.0458	.0408
1975	.105	.1057	-.0006
		Average Rate:	.0380

Chapter 4

Income Tax and Royalty Legislation

The four pieces of legislation of concern to the study are: (i) the Income Tax Act (Canada) as of 1969; (ii) the Income Tax Act (Canada) as of 1977; (iii) the Mining Royalty and Tax Act (Manitoba) as of 1969, and; (iv) the Metallic Minerals Royalty Act (Manitoba) as of 1977. Manitoba income tax, as is the case in most provinces, is assessed and collected according to federal legislation. The provinces set a separate tax rate which is then applied to the taxable income base as determined by the Federal Act. For firms operating in more than one province, taxable income is allocated in proportion to the simple average of (i) the fraction of total wages and salaries paid in a province, and (ii) the fraction of total sales occurring in a province. Royalty and mining tax legislation, on the other hand, are exclusively the responsibility of the provinces.

4.1 Income Tax Act as of 1969

During the years immediately preceding the 1972 tax reforms, Metal Mining was the lowest taxed of all sectors in Canada. For the five year period from 1967 to 1971 the effective tax plus royalty rate in Metal Mining averaged 24.26 percent as compared to 41.83 percent for Manufacturing and 33.0 percent for All Industries.[1] The low rate in Metal Mining reflected, in part, the various incentive schemes and special provisions directed at the mineral resource sector which had been introduced into the Income Tax Act since its introduction in 1917.[2]

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[1]From Appendix I to Chapter 1.

[2]The special provisions applicable to mineral resources are discussed by Trimbrell, D. Y., and Anson-Cartwright, H., Studies of the Royal Commission on Taxation, Number 9, Taxation of the Mining Industry in Canada (Ottawa: Queen's Printer, 1967).

Automatic Depletion Allowance

The first of these special provisions was the percentage depletion allowance. Initially the allowance was 25 percent of profit after all other deductions but was later raised to 33 1/3 percent of profit. It was a special provision in that (i) it was an annual deduction from profit which continued so long as a firm made a profit rather than being a deduction which was related to the cost of acquiring a depleting asset (the ore body), and (ii) it was available to all resource companies including those which did not own the resource but rather paid a royalty to the Crown or another person for the right to "win and remove" the minerals from the property. This allowance remained a feature of the Income Tax Act until the end of 1973.

Capital Cost Allowances

A second tax advantage available to the resource sector was the opportunity to utilize larger than normal capital cost allowances. From 1917 to 1946, the amount of the allowance was at the discretion of the Minister. In practice, the maximum amount claimable was usually 15 percent of the original cost of buildings and machinery. After 1946 the rate was set by regulation. The regulation under the Income Tax Act, 1948 set the maximum allowable depreciation rate at 30 percent of the undepreciated cost of buildings and machinery. Ongoing development costs including mine shafts and main haulage ways could be recovered up to the full amount from current income. For other industries, the depreciation rates would usually be limited to 5 percent on buildings and 20 percent on production machinery. Permanent roads, dams, bridges, etc. would be depreciated 4 percent in all industries.

Preproduction Exploration and Development

A third factor favouring the resource sector was the tax provision allowing that the preproduction exploration and development costs for a project could be recovered immediately from other mining income rather than recovered either at normal depreciation rates or from the income of the new project. This provision originated during World War II as part of the Income War Tax Act. It began as a tax credit to mining companies amounting to a maximum of 40 percent of exploration expenditure incurred by the company in Canada in search of base metals or strategic minerals. The original provision was applicable to the period, January 1, 1943 to December 31, 1945, but was later extended to cover the years 1946 and 1947. In 1948 the tax credit was replaced by a method of simply deducting such expenditure from income. The expenditure was not limited strictly to exploration but included development expenditures (for other than depreciable assets) that were incurred for a new mine up to the time commercial production could begin. From 1948 to 1954 the provision was enacted on a year by year basis. In 1955 it was made a permanent part of the Income Tax Act.

Three Year Tax Exemption

The tax provision providing the greatest economic benefit to the resource sector was the three year tax exempt period for the income from a new project. This provision was first introduced in 1936 and was to last until the end of 1939. The exemption applied to any metalliferous mine but was aimed primarily at gold mining. In 1939 the provision was extended for another three years to the end of 1942. All mines were now to receive the exemption. During the war the temporary Excess Profits Tax Act contained a similar feature. It would exempt from tax the income from a new mine brought into production from 1943 to the end of 1945 for a three year period. The provision was then extended to be in effect so long as the Excess Profits Tax Act was in effect. The exemption was continued in the new Income Tax Act, 1948 under section 74. In 1949 the importance of the exemption was significantly increased when resource companies were not required to deduct the capital cost allowances on the new investment until after the three year tax holiday. From 1948 to 1955 the exemption was reviewed annually after which it became a permanent feature of the Act.

Determining the Income Tax Liability

A mining firm[3] would calculate its taxable income for 1969 as follows:

(1) For the first 3 years production from a mine:

from: Gross Revenue
deduct: Operating Costs
deduct: Royalty/Mining Taxes
deduct: Interest on Long Term Debt
gives: Net Profit (tax exempt)

(2) Following the tax exempt period:

from: Gross Revenues
deduct: Operating Costs
deduct: Royalty/Mining Taxes
deduct: Interest on Long Term Debt
deduct: Exploration and Development Costs (100%)
deduct: Capital Cost Allowance (30% declining balance)
gives: Net Profit
deduct: Depletion Allowance (33 1/3% of Net Profit)
deduct: Prior Losses (up to 5 previous years)
gives: Taxable Income

[3] A mining firm is defined as a firm that mined and processed ore up to the refined metal stage.

If the taxable income were negative, the loss could be carried back one year, income permitting.

Royalties were fully deductible in arriving at taxable income but the deductibility of the mining profits tax was limited to the ratio of Mine Profit (Income Tax) divided by Mine Profit (Mining Tax), not to exceed one. Mine profit according to the income tax act was gross profit less the normal capital cost allowance less the processing allowance (as calculated for the mining tax). Mine Profit under the Manitoba mining tax act was gross profit less depreciation less the processing allowance. The mining tax act is described more fully in section 4.3.

The final tax calculation would be as follows:

Federal income tax:	.11 x taxable income up to $35,000
:	.40 x taxable income in excess of $35,000
Manitoba income tax:	.11 x taxable income

4.2 Income Tax Act as of 1977

The first major reforms to the Income Tax Act were implemented in 1972 after years of study and debate. The period from 1972 to 1976 was one of transition from the old act to what would amount to a completely new act.

Automatic Depletion Allowance Replaced

An important change was the elimination of the automatic depletion allowance. Its place was taken by an "earned depletion" system. This operates as follows. As of 1969, a resource company would establish an earned depletion bank. Additions to the bank would be an amount equal to one-third the cost of qualifying investment in a new project. Qualifying investment includes exploration, preproduction development, mine assets, processing assets, and the required service assets. Social capital assets would not be included.[4] Investments leading to a 25 percent expansion of an existing facility would also qualify. Deductions from the bank were to begin in 1977 but this was later revised to 1974. The maximum deduction permitted was 25 percent of the profit before the deduction up to the amount remaining in the earned depletion bank. In the sequence of deductions to arrive at taxable income, the earned depletion allowance replaced the automatic depletion allowance.

Preproduction Development Costs Recoverable at a Maximum Rate of 30 Percent

Beginning in 1974 preproduction development costs were recoverable at a lower rate than exploration costs. The rate was set at 30 percent of the undepreciated cost, the same as for depreciable assets. Exploration costs would continue to be fully deductible in the year incurred. Preproduction development costs now include the cost of acquiring the rights to a resource property. Previously such costs were excluded from any category of depreciable asset.

Provincial Mining Taxes Not Deductible

A 1974 amendment to the Income Tax Act disallowed provincial mining taxes as a deductible expense. This was replaced by an additional 15 point reduction in the Federal tax rate. One purpose of this amendment was to preserve the Federal income tax base in those provinces where the mining tax assessments had become quite large. In 1976, the 15 percent abatement was withdrawn and an automatic resource allowance implemented. The resource allowance is 25 percent of profit after deducting the depreciation allowance

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[4]A 1978 amendment now allows their inclusion.

[5]A 1978 amendment has restored the provision which allows preproduction development costs to be recovered at up to 100 percent of the undepreciated cost.

but before deducting interest, exploration costs, and preproduction development costs. In most provinces the allowance has proven to be larger than the royalty-mining tax assessments.

Three Year Tax Exemption Removed

The revision to the Income Tax Act that resulted in the greatest increase in the taxes of a resource company was the elimination of the three year tax holiday. The effect of this was partially off-set through the introduction of accelerated capital cost allowance provisions. The allowance for new mining, processing, service and social capital investment could be the greater of (i) new mine income (limited to 100 percent of the undepreciated balance), or (ii) 30 percent of the undepreciated balance. Investments for a 25 percent expansion of a facility would also qualify for the fast write-off, but associated social capital costs would be excluded. For 1972 and 1973 a company could either continue with the three-year exemption or use the accelerated allowance provisions. If the latter option is chosen, investments as of 1969 or later would qualify.

Because the capital cost allowance can be at least 30 percent of the undepreciated balance of mining and processing depreciable assets, the opportunity exists for a mining firm with no other income to increase the effectiveness of the resource allowance as a tax shelter.[6] A firm does this by claiming a capital cost allowance during the preproduction phase of a project which then becomes a taxable loss and can be carried forward for up to five years. Because losses are deducted after the resource allowance, they will not diminish the size of the resource allowance once production commences. Capital cost allowances, on the other hand, are deducted before

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[6] Holland, E., and Kemp, R., Canadian Taxation of Mining Income, (Toronto: CCH Canadian Limited, 1978), p. 72.

the resource allowance and therefore will reduce the resource allowance base.

Determining the Income Tax Liability

A mining firm would calculate its taxable income for 1977 as follows:

from:	Gross Revenue
deduct:	Operating Costs
deduct:	Capital Cost Allowance (100%)
deduct:	Capital Cost Allowance (30% declining balance)
gives:	Gross Profit
deduct:	Resource Allowance (25% of Gross Profit)
deduct:	Interest
deduct:	Preproduction Development (30% declining balance)
deduct:	Exploration (100%)
gives:	Net Profit
deduct:	Depletion Allowance (max. 25% of Net Profit)
deduct:	Prior Losses (for up to 5 years)
gives:	Taxable Income

As before, a taxable loss must be carried back one year, income permitting.

The final income tax calculation is:

Federal tax: .36 x Taxable Income

Provincial tax: .15 x Taxable Income.

The federal tax can be reduced by a tax credit provision implemented by the federal government in 1975. Its purpose is to stimulate new investment. For the mining industry, 5 percent of the cost of new mining (which includes processing), buildings and machinery would be the amount of the credit. The qualifying investment was to be made during the period June 1975 to July 1977 but the period is now extended beyond 1980. In any year the federal income tax payable would be reduced as follows:

(i) For income tax up to $15,000, the reduction is the lesser of the tax payable or the amount of the credit as yet unclaimed.

or

(ii) For income tax in excess of $15,000, the reduction is the lesser of $15,000 plus one-half of the tax in excess of $15,000, or the amount of the credit as yet unclaimed.

Any unused tax credit can be carried forward for up to five years. The amount of the credit used in any year also reduces the undepreciated balance of the buildings and machinery for purposes of the capital cost allowances.

4.3 Mining Royalty and Tax Act as of 1969

The royalty/mining tax assessment of copper-zinc producers began in Manitoba in December, 1947. Actual production of copper and zinc began in 1930 but an agreement between the federal government and the two base metal producers provided a 20 year royalty exempt period. This was justified on the grounds that the location of the deposits, being in an undeveloped part of Manitoba and far from a market, precluded any development without federal and provincial assistance.[7] The exemptions were granted by federal Orders-in-Council, number 2274, December 17, 1927 for Hudson Bay Mining and Smelting, and number 1656, October 13, 1928 for Sherritt Gordon Mines Ltd. The exemptions were to run from December 1, 1927 to December 1, 1947. When the mineral rights were passed from the Dominion to Manitoba in 1930, the province agreed to honour all previous commitments to the companies.

The Mining Royalty and Tax Act, S.M. 1948 assessed a royalty or

[7]Except for the obvious fact that the properties were located in different places, the description of the deposits, the job creating potential, plus the other circumstances presented to justify the 20 year exception were identical. Actually, the Sherritt Gordon deposit was about one-eighth the size of the HBMS deposit.

mining tax on all Crown or Freehold operators respectively except for those producing petroleum or natural gas. The assessment was determined as follows. First, the gross profit for a company was determined by deducting from sales revenue all production costs plus any exploration costs incurred in the province plus a depreciation allowance. The maximum allowance was 10% of the cost of the asset until the asset was fully depreciated. Second, processing profit was deducted since this was a "manufacturing" activity rather than strictly a mining activity. The processing allowance was 8 percent of the original cost of processing assets with (i) a minimum of 20 percent of total profit for copper-zinc mines or 40 percent for copper-nickel mines, and (ii) a maximum of 65 percent of total profit. The first 10 thousand dollars of mining profit was exempt and the remainder was assessed at 8 percent. For a new mine, the rate was 6 percent for the first year, and 7 percent for the second year.

In 1964 the royalty rates were amended to 6 percent on the first one million dollars of profit, 9 percent on the next four million dollars, and 11 percent on profit in excess of one million dollars. The next year an amendment provided that these rates be halved for the first three years' profit from a new mine. Another amendment extended the "new mines" category to mines established on or after January 1, 1962. In a 1966 amendment the minimum processing allowance was reduced to 15 percent of total profit.

To summarize, Mining Profit as of 1969 was determined as follows.

from: Gross Revenue

deduct: Operating Costs

deduct: Exploration Within the Province

deduct: Depreciation Allowance (10% straight line)

gives: Gross Profit

deduct: Processing Allowance (8% of the cost of processing assets; minimum is 15% of Gross Profit and a maximum is 65% of Gross Profit)

gives: Mining Profit

The royalty/mining tax comes to:

If Mine Profit is:	The Royalty Tax is:
0 - $1 million	.06 x Mine Profit
$1 million - $5 million	.09 x (Mine Profit - $1 million) + $60,000
$5 million and greater	.11 x (Mine Profit - $5 million) + $420,000

During the first three years production from a mine, the above rates were halved.

4.4 Metallic Minerals Royalty Act as of 1977

The Mining Royalty and Tax Act was replaced by the Metallic Minerals Royalty Act, effective January 1, 1975. The new act retained some aspects of the previous act but also contained a major innovation. Mining Profit in the new act was determined in the same general manner as the previous act but with two minor changes in the allowances. First, the depreciation allowance was changed from 10 percent straight line to 20 percent declining balance. Second, the upper limit of the processing allowance was reduced to 50 percent of total profit from 65 percent, and the lower limit (previously 15 percent) was removed.

The major innovation in the new act is a procedure for distinguishing abnormally high or "windfall" profits from normal profits and taxing these above-normal profits at a significantly higher rate than normal profits. Insofar as this higher than normal profit is economic rent, taxing away a larger portion of it would not, by definition, have an adverse effect on the level of capital investment in the province.

The procedure used to determine the normal level of profit for a firm is to multiply the undepreciated capital of the firm by the before-tax rate of return. For example, if the undepreciated balance for a firm amounted to $66.67 million and a reasonable before-tax rate of return is 18 percent, then a normal level of profit for that firm would be $12 million. This basic procedure is further refined in the new royalty act by indexing the undepreciated balance for inflation. Each year, this indexed undepreciated balance, called the Investment Base (IB) is adjusted upward for inflation and net new investment, and decreased by the depreciation claimed.

The Total Royalty for the year is calculated in the following steps.

(1) Calculate mining profit:

from:	Gross Revenue
deduct:	Operating Costs
deduct:	Exploration Within the Province
deduct:	<u>Depreciation Allowance</u> (20% declining balance)
gives:	Total Profit
deduct:	<u>Processing Allowance</u> (8% of the cost of processing assets; maximum is 50% of Total Profit; there is no minimum)
gives:	Mining Profit

(2) Calculate the Investment Base as of the <u>beginning</u> of the year (from the depreciation, inflation, and depreciation for the previous year). Since processing profit is removed in calculating Mining Profit, only mining and service investment will constitute the Investment Base. With C as the undepreciated balance of the depreciable assets and C' as

the Investment Base, the adjustments each year are as follows:

	Undepreciated Balance (at cost)	Investment Base (current $)
Opening balance	C_1	C_1'
Add inflation effect (rate r)	-	$C_1' \times r$
Add current investment	I	I
Gives	C_2	C_2'
Deduct depreciation (rate d)	$C_2 \times d$	$C_2' \times d$
Closing balance	C_3	C_3'

(3) Calculate the royalty payable:

(i) on profit up to $.18 \times C_3'$, Base Royalty (B.R.) = $.15 \times$ Mine Profit;

(ii) on profit in excess of $.18 \times C_3'$, Incremental Royalty (I.R.) = $.35(\text{Mine Profit} - .18 \times C_3')$;

(iii) The Total Royalty is the sum of that in (i) and (ii).

(4) To compensate for fluctuations in profit an averaging feature exists. The royalty in the third year of each fixed three year period is determined in the following steps:

(i) sum the Investment Bases for the 3 years (call this C);

(ii) sum the Mining Profit for the 3 years (call this P);

(iii) on profit up to the amount $.18 \times C$, Base Royalty = $.15 \times P - (B.R._1 + B.R._2)$;

(iv) on profit in excess of $.18 \times C$, Incremental Royalty = $.35(P - .18 \times C) - (I.R._1 + I.R._2)$;

(v) Total Royalty is the sum of that in (iii) and (iv).

The intent of the royalty system is to capture a larger percent of the economic rent for the province without significantly altering the investment climate or affecting decisions on the amount of ore. The procedure used results in the system being relatively neutral between different sizes of firm, unlike most multi-tiered tax or royalty systems in that the larger the mining firm, the larger will be the Investment Base. However, as will be shown, it is very inadequate in compensating for the effects of inflation with the likely result that it would have a discernable adverse effect on the investment climate.

Chapter 5

Results of the Analysis

The results of the analysis are summarized in two sets of tables. The first set, Tables 5.1 to 5.6, show the effects of changes in the tax legislation and in relative prices from the point of view of a private firm. The second set, Tables 5.7 to 5.12, show the effects of changes in the tax legislation and relative prices from the point of view of the province. Within each set of tables, there are two tables per project for each of the three projects. The first table shows the actual project parameters determined by each experiment, the second the percentage change in each of the values from those initially established for 1969. The project characteristics determined by the program and compared are production rates, primary ore available, the private value of the primary ore, the net surplus from the primary ore, the economic rent from the primary ore, net taxes and royalties from the primary ore and gross investment for the project. As discussed before, it is the private value of the primary ore or the net surplus from the primary ore which will be maximized in each experiment. Project characteristics were also determined for total ore production and are shown in Appendix I to this chapter. Where the total ore production gives results which are not consistent with the results from the primary ore production, this will be indicated.

5.1 Results From the Point of View of a Mining Firm

The project parameters of most concern to a private firm are the private value, the amount of primary ore, and the gross investment necessary. The private value of a project is the present value of the net cash flow

Table 5.1

Project #1 Change in Parameters

With Changes in Legislation and Prices

Experiment / Parameter	No.3 1969 Prices 1969 Taxes 1969 Royalties	No.5 1969 Prices 1977 Taxes 1969 Royalties	No.6 1969 Prices 1969 Taxes 1977 Royalties	No.7 1969 Prices 1977 Taxes 1977 Royalties	No.9 1977 Prices 1969 Taxes 1969 Royalties	No.10 1977 Prices 1977 Taxes 1977 Royalties	No.4 1969 Inflation 1969 Prices 1969 Taxes 1969 Royalties	No.11 1977 Inflation 1977 Prices 1977 Taxes 1977 Royalties
Production Rate	107,561	85,394	102,185	53,088	99,443	49,802	110,344	49,472
Primary Ore	281,015	276,853	272,539	275,634	265,887	260,032	280,334	253,550
Private Value	643,020	-359,811	-249,836	-907,967	-77,152	-1,157,557	650,359	-1,515,060
Net Surplus	70,072	167,458	81,997	205,614	-761,383	-630,907	83,006	-632,697
Economic Rent	785,292	-237,367	995,150	-143,179	52,021	-632,102	804,349	-786,943
Net Taxes and Royalties	-1,197,630	17,075	-126,945	606,227	-1,194,656	74,350	-1,189,886	510,383
Gross Investment	6,108,907	5,895,442	6,057,903	5,561,679	6,031,719	5,525,197	6,135,053	5,521,496

Note: 1 All value is in 1969 dollars.

2 The Production Rate is in tons of ore processed per year; Primary Ore is in tons.

3 Experiments other than No. 4 and No. 11 exclude inflation.

Table 5.2

Project #1 Percent Change in Parameters

With Changes in Legislation and Prices

Experiment / Parameter	No.3 1969 Prices 1969 Taxes 1969 Royalties	No.5 1969 Prices 1977 Taxes 1969 Royalties	No.6 1969 Prices 1969 Taxes 1977 Royalties	No.7 1969 Prices 1977 Taxes 1977 Royalties	No.9 1977 Prices 1969 Taxes 1969 Royalties	No.10 1977 Prices 1977 Taxes 1977 Royalties	No.4 1969 Inflation 1969 Prices 1969 Taxes 1969 Royalties	No.11 1977 Inflation 1977 Prices 1977 Taxes 1977 Royalties
Production Rate	*	-20.61	- 5.00	-50.64	- 7.55	-53.70	*	-55.17
Primary Ore	*	- 1.48	- 3.02	- 1.91	- 5.38	-7.47	*	- 9.55
Private Value	*	-155.96	-138.85	-241.20	-112.00	-280.02	*	-322.96
Net Surplus	*	+138.98	+ 17.02	+193.43	-1186.57	-1000.37	*	-862.23
Economic Rent	*	-130.23	+ 26.72	-118.23	- 93.38	-180.49	*	-197.84
Net Taxes and Royalties	*	-101.43	- 89.40	-150.62	- 0.25	-106.21	*	-142.89
Gross Investment	*	- 3.49	- 0.83	- 8.96	- 1.26	- 9.56	*	-10.00

Table 5.3

Project #2 Change in Parameters

With Changes in Legislation and Prices

Experiment / Parameter	No.3 1969 Prices 1969 Taxes 1969 Royalties	No.5 1969 Prices 1977 Taxes 1969 Royalties	No.6 1969 Prices 1969 Taxes 1977 Royalties	No.7 1969 Prices 1977 Taxes 1977 Royalties	No.9 1977 Prices 1969 Taxes 1969 Royalties	No.10 1977 Prices 1977 Taxes 1977 Royalties	No.4 1969 Inflation 1969 Prices 1969 Taxes 1969 Royalties	No.11 1977 Inflation 1977 Prices 1977 Taxes 1977 Royalties
Production Rate	885,090	785,750	783,697	485,038	739,109	414,077	884,105	363,665
Primary Ore	2,658,835	2,833,669	2,469,287	2,984,209	2,262,258	2,560,888	2,654,979	2,221,855
Private Value	18,320,396	11,281,860	10,277,130	4,294,072	11,379,020	2,377,916	18,202,121	1,012,152
Net Surplus	24,136,951	25,644,469	24,369,502	27,071,111	15,264,094	17,470,377	24,105,940	16,855,072
Economic Rent	19,748,465	12,776,408	20,272,353	12,935,626	12,439,390	8,355,173	19,678,635	7,312,519
Net Taxes and Royalties	-875,674	9,536,193	9,498,690	19,452,409	-945,968	12,482,780	-812,363	13,752,103
Gross Investment	19,820,135	18,307,412	18,276,124	13,708,351	17,593,254	12,607,667	19,805,147	11,827,895

Note: 1 All value is in 1969 dollars.

2 The Production Rate is in tons of ore processed per year; Primary Ore is in tons.

3 Experiments other than No. 4 and No. 11 exclude inflation.

Table 5.4

Project #2 Percent Change in Parameters

With Changes in Legislation and Prices

Experiment / Parameter	No.3 1969 Prices 1969 Taxes 1969 Royalties	No.5 1969 Prices 1977 Taxes 1969 Royalties	No.6 1969 Prices 1969 Taxes 1977 Royalties	No.7 1969 Prices 1977 Taxes 1977 Royalties	No.9 1977 Prices 1969 Taxes 1969 Royalties	No.10 1977 Prices 1977 Taxes 1977 Royalties	No.4 1969 Inflation 1969 Prices 1969 Taxes 1969 Royalties	No.11 1977 Inflation 1977 Prices 1977 Taxes 1977 Royalties
Production Rate	*	-11.22	-11.46	-45.20	-16.49	-53.22	*	-58.87
Primary Ore	*	+ 6.58	- 7.13	+12.24	-14.92	- 3.68	*	-16.31
Private Value	*	-38.42	-43.90	-76.56	-37.89	-87.02	*	-94.73
Net Surplus	*	+ 6.25	+ 0.96	+12.16	-36.76	-27.62	*	-30.08
Economic Rent	*	-35.30	+ 2.65	-34.50	-37.01	-57.69	*	-62.84
Net Taxes and Royalties	*	-1189.01	-1184.73	-2321.42	+ 8.03	-1525.51	*	-1792.85
Gross Investment	*	- 7.63	- 7.79	-30.84	-11.17	-36.39	*	-40.28

Table 5.5

Project #3 Change in Parameters

With Changes in Legislation and Prices

Experiment / Parameter	No.3 1969 Prices 1969 Taxes 1969 Royalties	No.5 1969 Prices 1977 Taxes 1969 Royalties	No.6 1969 Prices 1969 Taxes 1977 Royalties	No.7 1969 Prices 1977 Taxes 1977 Royalties	No.9 1977 Prices 1969 Taxes 1969 Royalties	No.10 1977 Prices 1977 Taxes 1977 Royalties	No.4 1969 Inflation 1969 Prices 1969 Taxes 1969 Royalties	No.11 1977 Inflation 1977 Prices 1977 Taxes 1977 Royalties
Production Rate	5,453,022	4,225,564	4,385,987	3,269,024	4,187,238	2,711,024	5,896,809	1,869,886
Primary Ore	22,958,674	26,468,578	23,583,514	26,651,804	19,832,133	22,151,833	21,030,776	17,653,212
Private Value	112,502,699	78,822,695	71,481,434	35,949,043	77,415,854	25,006,090	109,794,567	16,450,017
Net Surplus	196,538,052	218,886,703	210,066,976	224,371,983	145,254,389	162,400,363	183,708,833	153,117,115
Economic Rent	123,860,383	91,403,628	129,309,038	90,096,048	86,599,947	64,127,131	120,788,501	55,215,603
Net Taxes and Royalties	29,196,041	93,400,378	96,005,574	157,549,349	26,282,174	113,280,465	21,464,293	118,048,562
Gross Investment	98,802,957	78,467,182	81,116,921	62,592,573	77,873,046	53,359,852	106,156,688	39,372,200

Note: 1. All value is in 1969 dollars.

2. The Production Rate is in tons of ore processed per year; Primary Ore is in tons.

3. Experiments other than No. 4 and No. 11 exclude inflation.

Table 5.6

Project #3 Percent Change in Parameters

With Changes in Legislation and Prices

Experiment / Parameter	No.3 1969 Prices 1969 Taxes 1969 Royalties	No.5 1969 Prices 1977 Taxes 1969 Royalties	No.6 1969 Prices 1969 Taxes 1977 Royalties	No.7 1969 Prices 1977 Taxes 1977 Royalties	No.9 1977 Prices 1969 Taxes 1969 Royalties	No.10 1977 Prices 1977 Taxes 1977 Royalties	No.4 1969 Inflation 1969 Prices 1969 Taxes 1969 Royalties	No.11 1977 Inflation 1977 Prices 1977 Taxes 1977 Royalties
Production Rate	*	-22.51	-19.57	-40.64	-23.21	-50.28	*	-68.29
Primary Ore	*	+15.29	+ 2.72	+16.09	-13.62	- 3.51	*	-16.06
Private Value	*	-29.94	-36.46	-68.05	-31.19	-77.77	*	-85.02
Net Surplus	*	+11.37	+ 6.88	+14.16	-26.09	-17.37	*	-16.65
Economic Rent	*	-26.20	+ 4.40	-27.26	-30.08	-48.23	*	-54.29
Net Taxes and Royalties	*	+219.91	+228.83	+439.63	- 9.98	+288.00	*	+449.98
Gross Investment	*	-20.58	-17.90	-36.65	-21.18	-45.99	*	-62.91

using the supply price of capital as a discount rate. It is the maximum price the firm would be prepared to pay another firm for the rights to the resource.

The estimated tonnage of primary ore in a property will delimit the size and life of a possible project. It varies with the discount rate used, the income tax and royalty legislation in place, and the costs and prices assumed.

The gross investment determined for a project is the amount of capital which must be raised by the developer. It is assumed in this study that capital will be raised by equity capital although for Project numbers 1 and 2 some capital will be available by way of the tax saving. Changes in gross investment are highly correlated with changes in production rates since the production rate is a direct function of project size.

<u>Initial Conditions, 1969</u>

Experiment number 3 for each of the projects establishes the parameters that would be optimum given 1969 taxes, royalties, and relative prices. Generally, the 1969 projects are characterized by relatively high private values, low amounts of primary ore, and high gross investments. An exception to this is the relatively high level of primary ore for Project number 1. This results because of the combined effect of no taxes, small royalties and a primary ore production period which is naturally close to the three-year tax holiday. The high level of investment and associated high production rates are directly attributable to what would be rational response of the firm to the three-year tax holiday. The strategy of the firm is to mine most of the primary ore within the tax free period so as to maximize the value of the deposit. The three-year period of reduced royalty rates reinforces this response, although the influence is obviously weaker.

For Project numbers 1 and 2, the net taxes and royalties are low or negative. This occurs because of the combined effect of low gross taxes and royalties and the foregone taxes at the time of investment.

1977 Income Taxes

Experiment number 5 replaces the 1969 income tax regime with that in place as of 1977. In the new income tax legislation the automatic depletion allowance is replaced by earned depletion and the three-year tax holiday is replaced with accelerated capital cost allowances. The general effects are that private values, gross investment and annual production rates fall while the amount of primary ore (with one exception) increases. Project number 1 primary ore is not increased because the amount of primary ore was already relatively high since the three-year tax holiday had little effect on production rates. These effects and the resulting increase in project life are the logical consequence of the elimination of the three-year tax holiday. The changes in production rates from those in Experiment number 3 varies from an 11 percent reduction for project number 2 to about a 20 percent reduction for the other projects.

The most important change for a private firm is the reduction in the private value of each project that occurs. For Project number 1, the income taxes have increased to the extent that the project is no longer economically viable. The value for Project numbers 2 and 3 declined by 38 percent and 30 percent respectively. Most of the change results from elimination of the tax holiday. However, limiting the rate at which pre-production development costs could be recovered from other income also has a significant effect, especially for the smallest project.

1977 Royalties

The introduction of the 1977 royalty system in Experiment number 6 results in similar changes to those produced by the 1977 income taxes but there are some significant differences as well. The private value of the projects are reduced by almost the same extent as they were in the previous experiment. As with Experiment number 3, Project number 1 is no longer economically viable. The value of Project numbers 2 and 3 are reduced by 44 percent and 36 percent respectively, slightly more than occurred with the previous experiment.

The tonnage of primary ore is affected relatively little by the new royalty system even when the project size is significantly reduced as with Project number 3. This can be attributed to the high incremental royalty rate which would tend to keep the primary ore cut-off grade high.

The gross investment in each project is reduced but not as much as before. The new royalty system tends to have less effect on the smaller, less profitable projects than the larger, more profitable ones. Two off-setting factors produce this result. One is the three-year tax holiday which encourages a higher rate of production and more investment; the other is the two-tiered royalty system which encourages a lower production rate and smaller investment.

1977 Income Taxes and Royalties

When both the 1969 income tax and 1969 royalty systems are replaced by the 1977 legislation (Experiment number 7) there are substantial changes in all the projects. As with Experiment numbers 5 and 6, Project number 1 is not economically viable for a private firm. The decline in the private value of each project amounted to nearly the sum of the declines which each experienced in the previous two experiments. The reduction in private value for Project numbers 1, 2 and 3 amounted to 241 percent, 77 percent and 68 percent respectively.

The amount of primary ore, on the other hand, tends to increase because of the new legislation. The increases for Project numbers 2 and 3 are not large, 12 percent and 16 percent respectively, but they more than offset the loss from Project number 1 because it is no longer economically viable. The increases are the result of lower production rates and lower primary ore cut-off grades once the tax holiday is eliminated.

As production rates decrease, so do the levels of gross investment. The decline for Project numbers 2 and 3 amounts to 31 percent and 37 percent respectively.

1977 Prices

Experiment number 9 combines 1977 costs and prices with 1969 income taxes and royalties. In comparison with the initial 1969 results, the effect on all three projects is a decline in private values, a decline in the amount of primary ore, and a decline in gross investment. However, the magnitude of the changes is generally much smaller than occurred in the previous experiment when the 1977 legislation was in effect.

The decline in the private value of each of the projects from the values determined for Experiment number 3 amounts to 112 percent, 37.9 percent, and 31.2 percent. These are just under one-half the amounts which occurred in the previous experiment. Again note that Project number 1 is no longer profitable for a private firm to undertake.

The introduction of 1977 costs and prices had a considerable adverse effect on the amount of primary ore. The reduction amounted to 15 percent and 14 percent for Project numbers 2 and 3 respectively. Similarly gross investment and production rates were also reduced. Project numbers 2 and 3 gross investments were reduced by 21 percent each, just over one-half the decline that occurred in the previous experiment.

1977 Prices Plus 1977 Taxes and Royalties

The results from Experiment number 10 show the full extent of the changes in project parameters since 1969. Fortunately the changes are less than a single summation of the results from the previous two experiments would produce. That is, a reduction in private value of a project by, say, 10 percent in each of the two previous experiments does not result in a 20 percent reduction in private value in this experiment. This is because a firm can determine another variation of the project which will increase the private value over that which would result if the previous variations of the project were used.

The private value of Project number 1 is reduced by about 280 percent from 1969. Naturally, as was the case with each of the previous changes, this project is not economically viable for a private firm. Project number 2 value has declined by 87 percent from 1969 while Project number 3 value is down by 78 percent. Project number 2, which would develop deposits in the one million to 10 million ton range, is now little more than a marginal project. This likely means that it would only be undertaken by a nearby mining firm already established. Although the private value of the projects is considerably reduced in this experiment, the amount of primary ore is relatively unaffected. It is reduced by 8 percent for Project number 2, and 3 percent for Project number 3. This is the net effect of the changed economic conditions (which reduces the amount of the ore) and the new legislation (which tends to increase it).

The optimum level of investment that would be made in Project numbers 2 and 3 is reduced to nearly half of what would take place in 1969. The changes here parallel the changes in production rates with small deviation because of differences in the tax and royalty legislation relating to capital recovery allowances.

1969 Conditions With Inflation

Experiment number 4 is the same as Experiment number 3 with the exception that the 1969 rate of inflation is applied to anticipated future costs and revenues, and to the discount rates. The 1969 rate of inflation was relatively low, about 4.8 percent. A comparison of project parameters determined in Experiment numbers 3 and 4 shows that the effects of the 1969 inflation are quite small.

The general effects of the inflation are that private values decline, the amount of primary ore declines, and the level of investment declines. The changes reflect the net effect of two offsetting factors. First the use of a higher discount rate tends to accelerate the rate of production since the value of later production in relation to the value of current production is reduced. Second the existence of inflationary profit means that, in the absence of adequate indexing, taxes and royalties will increase and production rates will be reduced.[1] However, these effects can also be modified by the three-year tax holiday available in 1969. The private value of Project number 1 is actually increased slightly by inflation. This occurs as inflationary profits are introduced while income taxes remain at zero (since in both cases production occurs within the three-year tax free period). On the other hand, Project number 3 taxes and royalties declined because of inflation rather than increased. This occurred because more of the production took place within the three-year tax free period so that more

[1]The effects of a higher discount rate and increased costs is best demonstrated in the series of experiments undertaken from the province's point of view. Experiment number 2 differs from Experiment number 1 in that the discount rate is higher. The effect is to increase the rate of production and level of investment. Experiment number 8 differs from Experiment number 1 in that 1969 cost and prices are replaced by those for 1977. The effect is to lower the rate of production and level of investment.

of both the inflationary and real profits avoided taxation. However, the private value of the project declined as would be expected.

1977 Conditions With Inflation

Experiment number 11 is the same as Experiment number 10 except for the addition of the 1977 inflation. The rate was about 9.4 percent. The effect of inflation on project parameters is significantly greater in this experiment than was the case with Experiment number 4. For all projects, there is a noticeable decline in private value and the quantity of primary ore. The main reason is the significantly increased income tax and royalty assessments which cannot be avoided by way of the tax holiday.

An unexpected result was the large increase in the royalty assessments which occurred. The 1977 royalty system was designed so as to offset much of the effects of inflation. In fact the increase in mining profit (and therefore royalties) can amount to from three to four times the proper increase.[2] If this profit is assessed at the high royalty rate, the percentage increase in royalties is even greater.

As in the previous experiment, investment and production rates tend to be higher with the higher discount rate and be lower because of the relative increase in costs. The latter effect is generally more important. For Project number 1 there is only a small decrease in the optimum production rate. The effect is more important for Project numbers 2 and 3. Project number 2 production rate declines by nearly 15 percent while Project number 3 production rate declines by 35 percent. The importance of the effects is directly related to the profitability of the projects. Project number 1 is not economically viable for a private firm while Project number 3, on the

[2]This is demonstrated with a simple example in Appendix II to this chapter.

other hand, is significantly more profitable than is Project number 2. An important factor tending to retard the production rates is the two-tiered royalty system. Increasing costs alone have this effect, as discussed before. Since the 35 percent incremental royalty rate is applied to the inflationary profits, the royalty assessments increase, leading to a further decline in the rate of production. The strategy is, in effect, to avoid or postpone the high royalty payments by postponing production.

Comparing the percentage change in project parameters from Experiment number 3 to Experiment number 10 (no inflation) with the percentage change in project parameters from Experiment number 4 to Experiment number 11 (with inflation) provides the clearest indication of how a firm might be affected by inflation. For the economically viable projects, the expected changes occur. A high rate of inflation results in more taxes and royalties, reduced private value, reduced amounts of primary ore, reduced rates of ore extraction, and reduced levels of investment. Note in particular that the private value of Project number 2 declined by 95 percent with inflation compared to 87 percent without inflation while Project number 3 value declined by 85 percent with inflation compared to 78 percent without inflation.

5.2 Results From the Province's Viewpoint

The project parameters of most concern to the province are the net surplus, the net taxes and royalties, and the economic rent. As discussed previously, the net surplus represents the present value of social benefits which will accrue to the public sector in the form of taxes and royalties and to the private sector in the form of net profits. As Experiments number 1 through number 8 demonstrate, the social benefits which a

Table 5.7

Project #1 Change in Parameters

From Socially Optimum Values With Changes in the Discount Rate and Legislation

Experiment / Parameter	No. 1 1969 Prices 1969 Surplus D.R. is SOC	No. 2 1969 Prices 1969 Surplus D.R. is SPC	No. 3 1969 Prices 1969 Taxes 1969 Royalties	No. 5 1969 Prices 1977 Taxes 1969 Royalties	No. 6 1969 Prices 1969 Taxes 1977 Royalties	No. 7 1969 Prices 1977 Taxes 1977 Royalties	No. 8 1977 Prices 1977 Surplus D.R. is SOC
Production Rate	64,077	83,694	107,561	85,394	102,185	53,088	59,649
Primary Ore	288,374	276,925	281,015	276,853	272,539	275,634	273,008
Private Value	242,274	536,391	643,020	-359,811	-249,836	-907,967	-393,385
Net Surplus	224,732	174,653	70,072	167,458	81,997	205,614	-615,826
Economic Rent	357,830	659,798	785,292	-237,367	995,150	-143,179	-288,795
Net Taxes and Royalties	-764,698	-1,045,262	-1,197,630	17,075	-126,945	606,227	-843,288
Gross Investment	5,679,523	5,878,679	6,108,907	5,895,442	6,057,903	5,561,679	5,632,725

Note: 1. All value is in 1969 dollars.

2. The Production Rate is in tons of ore processed per year; Primary Ore is in tons.

3. Inflation is excluded.

Table 5.8

Project #1 Percent Change in Parameters

From Socially Optimum Values With Changes in the Discount Rate and Legislation

Experiment / Parameter	No. 1 1969 Prices 1969 Surplus D.R. is SOC	No. 2 1969 Prices 1969 Surplus D.R. is SPC	No. 3 1969 Prices 1969 Taxes 1969 Royalties	No. 5 1969 Prices 1977 Taxes 1969 Royalties	No. 6 1969 Prices 1969 Taxes 1977 Royalties	No. 7 1969 Prices 1977 Taxes 1977 Royalties	No. 8 1977 Prices 1977 Surplus D.R. is SOC
Production Rate	*	+30.61	+67.86	+33.27	+59.47	-17.15	-6.91
Primary Ore	*	- 3.97	- 2.55	- 4.00	- 5.49	- 4.42	-5.33
Private Value	*	+121.40	+165.41	-248.51	-203.12	-474.77	-262.37
Net Surplus	*	-22.28	-68.82	-25.49	-63.51	- 8.51	-374.03
Economic Rent	*	+84.39	+119.46	-166.34	+178.11	-140.01	-180.71
Net Taxes and Royalties	*	+46.69	+56.61	-102.23	-83.40	-179.28	+10.28
Gross Investment	*	+3.51	+7.56	+ 3.80	+6.66	- 2.07	-0.82

Table 5.9

Project #2 Change in Parameters

From Socially Optimum Values With Changes in the Discount Rate and Legislation

Experiment / Parameter	No. 1 1969 Prices 1969 Surplus D.R. is SOC	No. 2 1969 Prices 1969 Surplus D.R. is SPC	No. 3 1969 Prices 1969 Taxes 1969 Royalties	No. 5 1969 Prices 1977 Taxes 1969 Royalties	No. 6 1969 Prices 1969 Taxes 1977 Royalties	No. 7 1969 Prices 1977 Taxes 1977 Royalties	No. 8 1977 Prices 1977 Surplus D.R. is SCC
Production Rate	566,548	641,182	885,090	785,750	783,697	485,038	498,504
Primary Ore	3,242,367	2,949,461	2,658,835	2,833,669	2,469,287	2,984,209	2,826,144
Private Value	15,518,465	16,733,602	18,320,396	11,281,860	10,277,130	4,294,072	9,680,981
Net Surplus	27,260,297	26,832,923	24,136,951	25,644,469	24,369,502	27,071,111	17,687,690
Economic Rent	17,038,184	18,280,690	19,748,465	12,776,408	20,272,353	12,935,626	10,838,454
Net Taxes and Royalties	4,608,222	3,218,591	-875,674	9,536,193	9,498,690	19,452,409	2,768,559
Gross Investment	14,958,964	16,101,065	19,820,135	18,307,412	18,276,124	13,708,351	13,908,390

Note: 1. Value is in 1969 dollars.

2. The Production Rate is in tons of ore processed per year; Primary Ore is in tons.

3. Inflation is excluded.

Table 5.10

Project #2 Percent Change in Parameters

From Socially Optimum Values With Changes in the Discount Rate and Legislation

Experiment Parameter	No. 1 1969 Prices 1969 Surplus D.R. is SOC	No. 2 1969 Prices 1969 Surplus D.R. is SPC	No. 3 1969 Prices 1969 Taxes 1969 Royalties	No. 5 1969 Prices 1977 Taxes 1969 Royalties	No. 6 1969 Prices 1969 Taxes 1977 Royalties	No. 7 1969 Prices 1977 Taxes 1977 Royalties	No. 8 1977 Prices 1977 Surplus D.R. is SOC
Production Rate	*	+13.17	+56.23	+38.69	+38.33	-14.39	-12.01
Primary Ore	*	- 9.03	-18.00	-12.60	-23.84	- 7.96	-12.84
Private Value	*	+ 7.83	+18.06	-27.30	-33.77	-72.33	-37.62
Net Surplus	*	- 1.57	-11.46	- 5.93	-10.60	- 0.69	-34.71
Economic Rent	*	+ 7.29	+15.91	-25.01	+18.98	-24.08	-36.39
Net Taxes and Royalties	*	-30.16	-119.00	+106.94	+106.12	+322.12	-42.13
Gross Investment	*	+ 7.63	+32.50	+22.38	+22.18	- 8.36	- 7.02

Table 5.11

Project #3 Change in Parameters

From Socially Optimum Values With Changes in the Discount Rate and Legislation

Experiment / Parameter	No. 1 1969 Prices 1969 Surplus D.R. is SOC	No. 2 1969 Prices 1969 Surplus D.R. is SPC	No. 3 1969 Prices 1969 Taxes 1969 Royalties	No. 5 1969 Prices 1977 Taxes 1969 Royalties	No. 6 1969 Prices 1969 Taxes 1977 Royalties	No. 7 1969 Prices 1977 Taxes 1977 Royalties	No. 8 1977 Prices 1977 Surplus D.R. is SOC
Production Rate	3,315,427	4,105,522	5,453,022	4,225,564	4,385,987	3,269,024	2,820,747
Primary Ore	31,879,619	27,490,008	22,958,674	26,468,578	23,583,514	26,651,804	27,683,228
Private Value	97,844,192	107,989,499	112,502,699	78,822,695	71,481,434	35,949,043	68,405,858
Net Surplus	228,265,875	221,654,422	196,538,052	218,886,703	210,066,976	224,371,983	166,748,868
Economic Rent	110,130,023	120,902,542	123,860,383	91,403,628	129,309,038	90,096,048	77,664,056
Net Taxes and Royalties	66,348,641	53,912,692	29,196,041	93,400,378	96,005,574	157,549,349	49,402,450
Gross Investment	63,362,454	76,466,789	98,802,957	78,467,182	81,116,921	62,592,573	55,183,052

Note: 1. All value is in 1969 dollars.

2. The Production Rate is in tons of ore processed per year; Primary Ore is in tons.

3. Inflation is excluded.

Table 5.12

Project #3 Percent Change in Parameters

From Socially Optimum Values With Changes in the Discount Rate and Legislation

Experiment / Parameter	No. 1 1969 Prices 1969 Surplus D.R. is SOC	No. 2 1969 Prices 1969 Surplus D.R. is SPC	No. 3 1969 Prices 1969 Taxes 1969 Royalties	No. 5 1969 Prices 1977 Taxes 1969 Royalties	No. 6 1969 Prices 1969 Taxes 1977 Royalties	No. 7 1969 Prices 1977 Taxes 1977 Royalties	No. 8 1977 Prices 1977 Surplus D.R. is SCC
Production Rate	*	+23.83	+64.47	+27.45	+32.29	- 1.40	-14.92
Primary Ore	*	-13.77	-27.98	-16.97	-26.02	-16.40	-13.16
Private Value	*	+10.37	+14.98	-19.44	-26.94	-63.26	-30.09
Net Surplus	*	- 2.90	-13.90	- 4.11	- 7.97	- 1.71	-26.95
Economic Rent	*	+ 9.78	+12.47	-17.00	+17.41	-18.19	-29.48
Net Taxes and Royalties	*	-18.70	-56.00	+40.77	+44.70	+137.46	-25.54
Gross Investment	*	+20.68	+55.93	+23.84	+28.02	- 1.22	-12.91

project will yield vary with the discount rate used, the income tax and royalty regimes in effect, and, of course, relative prices.

The net taxes and royalties are the gross taxes and royalties less those foregone at the time of the initial investment. The present value of the net taxes and royalties represents the direct benefits the province would anticipate from a project.

The economic rent is the maximum lump sum amount the province, as owner of the resource, could ask the developer to pay for the rights to a resource property in lieu of annual royalty payments. Alternatively, the economic rent is the upper limit of the present value of the annual royalty payments that could be obtained from the private developer and leave the project just viable.

The Socially Optimum Projects in 1969

Experiment number 1 determines the socially optimum size for each of the projects. The model does this by maximizing the present value of the net surplus using the social opportunity cost as a discount rate. In addition to a high net surplus, the projects generally are characterized by a relatively low production rate, high net taxes and royalties, and high economic rent. Net taxes and royalties for Project number 1 are negative because few taxes and royalties are ever paid while considerable taxes are foregone at the time of investment. However, the net surplus is positive meaning that there are social benefits to be derived from the project. That is, the value of the profits generated plus the taxes and royalties paid will exceed the taxes foregone at the time of investment.

Changing the Discount Rate

Experiment number 2 is similar to Experiment number 1 except that the discount rate used is the supply price of capital. The parameters of the projects determined in this experiment can be compared to those in Experiment number 1 in order to measure the effects of using a discount rate higher than the socially optimum rate. As later experiments show, the income tax and royalty legislation in effect can either offset or contribute to the effects which occur as a result of using a discount rate which is too high.

Increasing the discount rate generally results in a higher rate of ore production, higher levels of investment for increased mine and mill capacity, less primary ore, a smaller net social surplus and reduced taxes and royalties. In other words, the use of a high discount rate imposes a cost on the province. A high discount rate may result from the private firm using a large risk premium (reflecting inadequate risk pooling) or from the firm operating in a monopolistic or oligopolistic market enabling it to maintain an abnormally high opportunity cost.

An increase in the discount rate has the greatest effect on the net surplus generated by the smallest project. The decrease amounts to 22.3 percent for Project number 1. For Project numbers 2 and 3, the decrease is relatively small, amounting to 1.6 percent and 2.9 percent respectively. Considering total possible ore production as opposed to only the primary ore production, the results for Project numbers 2 and 3 change slightly. That is, as the discount rate increases (so that the production rates increase and operating costs decrease), the net surpluses increase slightly. In these instances, the decline in surplus that occurs as the production rates move away from the socially optimum rates is more than offset by the lower average mining and concentrating costs which results in a lower final cut-off grade.

The decrease in net taxes and royalties that occurs as production rates increase amounts to 36.7 percent for Project number 1, 30.2 percent for Project number 2, and 18.7 percent for Project number 3. This decrease is matched by an increase in the private value. Also, the economic rent being inversely related to the income taxes payable, increases significantly for each of the projects as more of the production occurs during the tax free period.

1969 Taxes and Royalties

The introduction of the 1969 income tax and royalty legislation in Experiment number 3 results in a substantial loss of benefits for the province. This occurs for both the primary ore production and total ore production. The decline in primary surplus from the optimum values in Experiment number 2 for Project numbers 1, 2 and 3 amounts to 59.9 percent, 10.0 percent, and 11.3 percent respectively. Net taxes and royalties are at a minimum for all projects while the economic rent is relatively large.

The decline in surplus occurs in conjunction with the private firm's attempt to avoid income taxes and royalties by way of the tax holiday. This rational response by a private firm results in a substantial loss of benefits to the province. Using Project number 3 as an example, from Experiment number 2 to Experiment number 3 the loss in benefits amounts to more than $25 million.

1977 Income Taxes

Experiment number 5 introduces the 1977 income tax regime. Under the new tax system the three-year tax holiday is replaced by accelerated capital cost provisions, the automatic depletion is replaced by earned depletion, and development costs are no longer recoverable as quickly as income permits.

The general effect for all projects is an increase in net surplus and net taxes and royalties. This is largely the result of a reduction in the rates of production which are now closer to the socially optimum rates.

An undesirable consequence of the new tax regime is that Project number 1 is no longer economically viable for a private developer, although the loss in benefits to the province, as indicated by the net surplus, is small. If these potential benefits are to be realized through private development then further changes are needed in the income tax legislation. The gain in surplus for Project numbers 2 and 3 amounts to $1.5 million and $22.3 million respectively. The gain in total income taxes and royalties from these projects is even greater, amounting to $10.4 million for Project number 2 and $64.2 million for Project number 3. Naturally most of this is at the expense of profits which the developer would have received under the 1969 tax regime.

When total ore production is considered the increase in the net surplus is even greater. In fact for this experiment the total possible surplus exceeds that of Experiment number 1. This is a consequence of a slightly lower final cut-off grade coupled with a higher grade of primary ore (albeit, a smaller amount than in Experiment number 1). The effect is similar to high grading in that a smaller quantity of higher grade ore is mined first resulting in the higher present value of the surplus.

1977 Royalties

The 1977 royalty regime provides for a profits assessment at two different rates. The first is a basic royalty rate to be assessed on normal profits; the second is an incremental royalty rate to be assessed on above-normal profits. Normally a high incremental rate would result in a significant reduction in the optimum rate of production. However offsetting this in Experiment number 6 is the 1969 income tax system.

Generally, the influence of the 1969 income tax regime dominates that of the 1977 royalty system. The net surplus is increased for all projects but not nearly as much as occurred with the previous experiment. As in Experiment number 5, Project number 1 is no longer economically viable for a private developer, even with the three-year tax holiday. Since the project has potential social benefits, the royalty system is also to be faulted for making assessments even though there is no economic rent. In this particular case there was even a royalty assessment made at the 35 percent rate.

Project numbers 2 and 3 yield about the same net taxes and royalties as were determined in the previous experiment. In other words the increases in the royalty assessments were comparable in magnitude to the increases in the income tax assessments of the previous experiment. In each case there is a corresponding decline in the private value.

1977 Income Taxes and 1977 Royalties

Combining the 1977 income tax and royalty assessments has a dramatic effect on the parameters of all the projects. In each case the net surplus is larger than for any experiment except the socially optimum project (Experiment number 1). Note that the production rates have decreased from being well above the socially optimum rates to being a little below them. As discussed before the high incremental royalty rate in the royalty system is an important factor in this rate reduction.

As was the case with the 1977 income taxes and 1977 royalties separately, the increased income taxes and royalties have made Project number 1 uneconomic. The total tax and royalty increases for Project numbers 2 and 3 are roughly the sum of the increases determined in the previous two experiments.

1977 Prices

Experiment number 8 differs from Experiment number 1 only in that 1969 relative prices are replaced by those of 1977. This experiment shows that the characteristics of the socially optimum projects will also change as economic conditions change. Project number 1 is affected the most by the change in economic conditions. Under 1977 relative prices it is no longer able to provide any social benefits in addition to being economically unviable for a private firm. The net surpluses for Project numbers 2 and 3 are reduced by 35 percent and 27 percent respectively. This is almost exactly the reduction that occurred from Experiment number 3 to Experiment number 9 when the private value of the project was being maximized.

The optimum rate of ore extraction for Project numbers 1, 2 and 3 is reduced by 6.9 percent, 12 percent, and 14.9 percent respectively as a result of the decline in relative prices.

The more profitable projects are affected most by both the decline in relative prices and the increase in the rate of inflation, whereas the less profitable projects were affected most by the legislative changes. Generally, the legislative changes have been beneficial to the province. The elimination of the three-year tax holiday from the income tax act resulted in the greatest increase in the net surplus. The two-tiered royalty system further reduced production rates to nearer the socially optimum values, thereby offsetting some of the effects of a high private discount rate. Both the income tax legislation and the royalty legislation can be faulted for discouraging the development of marginal projects which would yield some social benefits.

APPENDIX I

DETAILED RESULTS OF EACH OF THE EXPERIMENTS

Table 1

Project #1

Primary Ore Production

Experiment	Rate (tons/yr)	Ave. Grade (%)	C-O Grade (%)	Ore (tons)	Life (yrs)
#1	64,077	3.982	1.452	288,374	4.50
#2	83,694	4.085	1.555	276,925	3.31
#3	107,561	4.048	1.518	281,015	2.61
#4	110,334	4.054	1.524	280,334	2.54
#5	85,394	4.086	1.556	276,853	3.24
#6	102,185	4.125	1.595	272,539	2.67
#7	53,088	4.097	1.567	275,634	5.19
#8	59,649	4.121	1.591	273,008	4.58
#9	99,443	4.188	1.658	265,887	2.67
#10	49,802	4.244	1.714	260,032	5.22
#11	49,472	4.308	1.778	253,550	4.13

Table 2

Project #1

Total Production

Experiment	C-O Grade (%)	Ore (tons)	Life (yrs)	Project Life (yrs)
#1	1.217	316,470	4.94	6.94
#2	1.189	319,983	3.82	5.82
#3	1.168	322,642	2.999	4.999
#4	1.656	322,967	2.93	4.93
#5	1.187	320,215	3.75	5.75
#6	1.170	322,471	3.16	5.16
#7	1.230	314,925	5.93	7.93
#8	1.333	302,356	5.07	7.07
#9	1.280	308,671	3.10	5.10
#10	1.346	300,767	6.04	8.04
#11	1.344	300,973	6.08	8.08

Table 3

Project #1

Primary Ore Profits and Taxes

Experiment	Value	Net Surplus	Economic Rent	Net Taxes and Royalties
#1	$ 242,274	$ 224,732	$ 357,830	$ -764,698
#2	536,391	174,653	659,798	-1,045,262
#3	643,020	70,072	785,292	-1,197,630
#4	650,359	83,006	804,349	-1,189,886
#5	-359,811	167,458	-237,367	17,075
#6	-249,836	81,997	995,150	-236,945
#7	-907,967	205,614	-143,179	606,227
#8	-734,831 (-393,385)	-1,150,345 (-615,826)	-539,460 (-288,795)	-1,575,236 (-843,288)
#9	-144,118 (-77,152)	-1,422,241 (-761,383)	97,174 (52,021)	-2,231,582 (-1,194,656)
#10	-2,162,282 (-1,157,557)	-1,178,516 (-630,907)	-1,180,747 (-632,102)	138,884 (74,350)
#11	-2,830,086 (-1,515,060)	-1,181,859 (-632,697)	-1,469,986 (-786,943)	953,380 (510,383)

Note: Figures in brackets are in 1969 dollars

Table 4

Project #1

Final Profits and Taxes

Experiment	Value	Net Surplus	Economic Rent	Net Taxes and Royalties
#1	$ 298,312	$ 242,157	$ 414,502	$ -833,818
#2	654,540	225,971	780,091	-1,156,713
#3	652,775	111,852	796,163	-1,195,754
#4	643,494	102,088	798,256	-1,188,421
#5	-336,764	220,996	-211,958	31,865
#6	-225,370	149,562	1,028,891	-110,260
#7	-899,433	248,622	-121,548	629,447
#8	-631,129 (-337,869)	-1,114,908 (-596,855)	-434,705 (-232,715)	-1,699,735 (-909,937)
#9	-110,487 (-59,148)	-1,337,414 (-715,972)	132,252 (70,800)	-2,228,939 (-1,193,241)
#10	-2,143,751 (-1,147,637)	-1,095,291 (-586,354)	-1,137,991 (-609,213)	180,808 (96,794)
#11	-2,812,848 (-1,505,831)	-1,083,103 (-579,829)	-1,417,853 (-758,034)	1,015,763 (543,779)

Note: Figures in brackets are in 1969 dollars

Table 5

Project #1

Gross Capital Costs[1]

Experiment	Exploration	Development	Mine	Mill	Service	Working Capital[2]	Total
#1	$ 293,376	$ 2,232,314	$ 922,978	$0.0	$1,714,534	$ 516,320	$ 5,679,523
#2	332,967	2,290,463	979,372	0.0	1,741,451	534,425	5,878,679
#3	370,157	2,361,211	1,047,984	0.0	1,774,200	555,355	6,108,907
#4	373,930	2,369,431	1,055,956	0.0	1,778,004	557,732	6,135,053
#5	335,947	2,295,503	984,259	0.0	1,743,784	535,949	5,895,442
#6	362,557	2,345,276	1,032,529	0.0	1,766,823	550,718	6,057,903
#7	265,489	2,199,740	891,388	0.0	1,699,456	505,607	5,561,679
#8	528,191	4,145,378	1,700,318	0.0	3,191,350	956,524	10,521,761 (5,632,725)
#9	669,713	4,365,722	1,914,010	0.0	3,293,346	1,024,279	11,267,071 (6,031,719)
#10	478,233	4,090,854	1,647,440	0.0	3,166,112	938,264	10,320,903 (5,525,197)
#11	476,392	4,089,027	1,645,668	0.0	3,165,266	937,635	10,313,988 (5,521,496)

Note: 1 Figures in brackets are in 1969 dollars

2 Preproduction only

Table 6

Project #1

Operating Costs

Experiment	Mining	Milling	Overhead	Total
#1	$ 7.600	$ 1.346	$ 1.342	$ 10.288
#2	7.416	1.346	1.314	10.076
#3	7.243	1.346	1.288	9.877
#4	7.225	1.346	1.286	9.857
#5	7.402	1.346	1.312	10.060
#6	7.278	1.346	1.294	9.918
#7	7.730	1.346	1.361	10.438
#8	14.189	2.515	2.521	19,324
#9	13.630	2.515	2.422	18.567
#10	14.522	2.515	2.555	19.592
#11	14.531	2.515	2.557	19.602

Table 7

Project #2

Primary Ore Production

Experiment	Rate (tons/yr)	Ave. Grade (%)	C-O Grade (%)	Ore (tons)	Life (yrs)
#1	566,548	3.105	1.465	3,242,367	5.72
#2	641,182	3.260	1.620	2,949,461	4.60
#3	885,090	3.430	1.790	2,658,835	3.004
#4	884,105	3.433	1.793	2,654,979	3.003
#5	785,750	3.326	1.686	2,833,669	4.61
#6	783,697	3.552	1.912	2,469,287	3.15
#7	485,038	3.241	1.601	2,984,209	6.15
#8	498,504	3.330	1.690	2,826,144	5.67
#9	739,109	3.695	2.055	2,262,258	3.06
#10	414,077	3.492	1.852	2,560,888	6.19
#11	363,665	3.725	2.085	2,221,855	6.11

Table 8

Project #2

Total Production

Experiment	C-O Grade (%)	Ore (tons)	Life (yrs)	Project Life (yrs)
#1	1.305	3,574,536	6.31	9.31
#2	1.267	3,657,368	5.70	8.70
#3	1.190	3,834,983	4.33	7.33
#4	1.190	3,834,650	4.34	7.34
#5	1.218	3,768,677	4.80	7.80
#6	1.211	3,784,826	4.83	7.83
#7	1.342	3,495,268	7.21	10.21
#8	1.526	3,123,265	6.27	9.27
#9	1.401	3,371,195	4.56	7.56
#10	1.585	3,012,566	7.28	10.28
#11	1.628	2,935,416	8.07	11.07

Table 9

Project #2

Primary Ore Profits and Taxes

Experiment	Value	Net Surplus	Economic Rent	Net Taxes and Royalties
#1	$ 15,518,465	$27,260,097	$17,038,184	$ 4,608,222
#2	16,733,602	26,832,923	18,280,690	3,218,591
#3	18,320,396	24,136,951	19,748,465	-875,674
#4	18,202,121	24,105,940	19,678,635	-812,363
#5	11,281,860	25,644,469	12,776,408	9,536,193
#6	10,277,130	24,369,502	20,272,353	9,498,690
#7	4,294,072	27,071,111	12,935,626	19,452,409
#8	18,083,782 (9,680,981)	33,040,074 (17,687,690)	20,245,907 (10,838,454)	5,171,585 (2,768,559)
#9	21,255,668 (11,379,020)	28,512,870 (15,264,094)	23,236,407 (12,439,390)	-1,767,039 (-945,968)
#10	4,441,876 (2,377,916)	32,634,140 (17,470,377)	15,607,212 (8,355,173)	23,317,458 (12,482,780)
#11	1,890,670 (1,012,152)	31,484,769 (16,855,072)	13,659,567 (7,312,519)	25,688,515 (13,752,103)

Note: Figures in brackets are in 1969 dollars

Table 10

Project #2

Final Profits and Taxes

Experiment	Value	Net Surplus	Economic Rent	Net Taxes and Royalties
#1	15,641,956	27,398,553	17,162,170	4,516,739
#2	17,314,599	27,583,862	18,871,652	3,059,570
#3	19,995,771	26,407,588	21,426,097	-879,474
#4	19,889,724	26,406,459	21,373,523	-807,888
#5	11,875,302	26,991,720	13,393,679	9,979,526
#6	12,286,457	27,255,304	22,697,736	9,558,920
#7	4,393,071	27,464,704	13,107,632	19,668,337
#8	18,299,504 (9,796,466)	33,244,188 (17,796,960)	20,465,226 (10,955,864)	4,981,702 (2,666,907)
#9	24,197,699 (12,954,008)	32,282,554 (17,282,159)	26,193,109 (14,022,232)	-2,049,935 (-1,097,413)
#10	4,602,448 (2,463,877)	33,218,588 (17,783,256)	15,868,835 (8,495,230)	23,613,201 (12,641,103)
#11	2,335,544 (1,250,311)	33,004,702 (17,668,754)	14,278,119 (7,643,655)	26,461,645 (14,165,990)

Note: Figures in brackets are in 1969 dollars

Table 11

Project #2

Gross Capital Costs[1]

Experiment	Exploration	Development	Mine	Mill	Service	Working Capital[2]	Total
#1	$ 616,446	$ 3,721,760	$ 2,367,459	$ 4,489,407	$ 2,403,985	$ 1,359,906	$ 14,958,964
#2	634,790	3,942,994	2,582,014	4,971,142	2,506,392	1,463,733	16,101,065
#3	682,577	4,665,997	3,283,190	6,545,478	2,841,064	1,801,830	19,820,135
#4	682,412	4,663,077	3,280,358	6,539,120	2,839,712	1,800,468	19,805,147
#5	664,930	4,371,529	2,997,611	5,904,275	2,704,757	1,664,310	18,307,412
#6	664,542	4,365,443	2,991,710	5,891,024	2,701,940	1,661,466	18,276,124
#7	593,420	3,480,145	2,133,138	3,963,290	2,292,144	1,246,214	13,708,351
#8	1,116,075	6,575,371	4,056,951	7,554,027	4,316,172	1,361,860	25,980,455 (13,863,671)
#9	1,225,125	7,907,630	5,348,989	10,461,458	4,932,862	2,987,606	32,863,671 (17,593,254)
#10	1,064,694	6,107,888	3,603,582	6,533,825	4,099,778	2,140,977	23,550,744 (12,607,667)
#11	1,028,748	5,828,751	3,332,871	5,924,655	3,970,568	2,008,559	22,094,153 (11,827,895)

Note: 1 Figures in brackets are in 1969 dollars

2 Preproduction only

Table 12

Project #2

Operating Costs

Experiment	Mining	Milling	Overhead	Total
#1	6.095	2.890	1.348	10.333
#2	6.010	2.750	1.314	10.074
#3	5.787	2.456	1.237	9.482
#4	5.788	2.457	1.237	9.482
#5	5.870	2.554	1.264	9.687
#6	5.871	2.556	1.264	9.692
#7	6.203	3.093	1.394	10.690
#8	11.552	5.706	2.589	19.846
#9	11.044	4.873	2.388	18.304
#10	11.791	6.228	2.703	20.721
#11	11.958	6.655	2.792	21.405

Table 13

Project #3

Primary Ore Production

Experiment	Rate (tons/yr)	Ave. Grade (%)	C-O Grade (%)	Ore (tons)	Life (yrs)
#1	3,315,427	2.270	1.150	31,879,619	9.62
#2	4,105,522	2.436	1.316	27,490,008	6.70
#3	5,453,022	2.638	1.518	22,958,674	4.21
#4	5,896,809	2.736	1.616	21,030,776	3.57
#5	4,225,564	2.478	1.358	26,468,578	6.26
#6	4,385,987	2.608	1.488	23,583,514	5.38
#7	3,269,024	2.471	1.351	26,651,804	8.15
#8	2,820,747	2.428	1.308	27,683,228	9.81
#9	4,187,238	2.802	1.682	19,832,133	4.74
#10	2,711,024	2.678	1.558	22,151,833	8.17
#11	1,869,886	2.932	1.812	17,653,212	9.44

Table 14

Project #3

Total Production

Experiment	C-O Grade (%)	Ore (tons)	Life (yrs)	Project Life (yrs)
#1	0.979	37,132,134	11.20	15.20
#2	0.946	38,266,644	9.32	13.32
#3	0.905	39,659,603	7.27	11.27
#4	0.893	40,087,020	6.80	10.80
#5	0.940	38,448,493	9.10	13.10
#6	0.931	38,625,505	8.84	12.84
#7	0.971	37,484,616	11.44	15.44
#8	1.125	32,602,180	11.56	15.81
#9	1.056	34,659,786	8.28	12.28
#10	1.120	32,745,385	12.08	16.08
#11	1.168	31,375,920	16.78	20.78

Table 15

Project #3

Primary Ore Profits and Taxes

Experiment	Value	Net Surplus	Economic Rent	Net Taxes and Royalties
#1	$ 97,844,192	$ 228,265,875	$110,130,023	$ 66,348,641
#2	107,989,499	221,654,422	120,902,542	53,942,692
#3	112,502,699	196,538,052	123,860,383	29,196,041
#4	109,794,567	183,708,833	120,788,501	21,464,293
#5	78,822,695	218,886,703	91,403,628	93,400,378
#6	71,481,434	210,066,976	129,309,038	96,005,574
#7	35,949,043	224,371,983	90,096,048	157,549,349
#8	127,780,091 (68,405,858)	311,481,882 (166,748,868)	145,074,126 (77,664,056)	92,282,294 (49,402,450)
#9	144,610,493 (77,415,854)	271,330,840 (145,254,389)	161,766,103 (86,599,947)	49,094,313 (26,282,174)
#10	46,710,626 (25,006,090)	303,359,006 (162,400,363)	119,787,557 (64,127,131)	211,604,510 (113,280,465)
#11	30,728,138 (16,450,017)	286,018,178 (153,117,115)	103,141,089 (55,215,603)	220,511,173 (118,048,562)

Note: Figures in brackets are in 1969 dollars

Table 16

Project #3

Final Profits and Taxes

Experiment	Value	Net Surplus	Economic Rent	Net Taxes and Royalties
#1	$ 98,743,355	$230,613,759	$111,055,922	$ 66,753,093
#2	113,471,506	232,957,504	126,436,316	55,458,688
#3	130,183,600	226,385,029	142,176,322	31,075,165
#4	131,529,932	222,796,761	143,467,774	26,624,378
#5	83,907,661	233,139,063	96,738,574	98,662,891
#6	82,743,584	234,139,499	142,158,552	101,000,454
#7	38,790,206	235,592,809	93,929,151	162,833,341
#8	129,347,413 (69,244,909)	315,483,204 (168,890,937)	146,671,045 (78,518,951)	93,027,561 (49,801,421)
#9	169,231,318 (90,596,379)	315,334,905 (168,811,547)	186,597,295 (99,893,090)	52,817,200 (28,280,540)
#10	51,853,143 (27,759,088)	324,217,188 (173,566,593)	126,798,869 (67,880,570)	221,361,481 (118,503,767)
#11	35,567,183 (19,040,554)	321,503,971 (172,114,098)	113,054,905 (60,522,870)	243,798,977 (130,515,467)

Note: Figures in brackets are in 1969 dollars

Table 17

Project #3

Gross Capital Costs[1]

Experiment	Exploration	Development	Mine	Mill	Service	Working Capital[2]	Total
#1	$ 878,341	$11,870,109	$10,269,813	$22,232,407	$12,351,561	$ 5,760,223	$ 63,362,454
#2	910,025	14,212,143	12,541,143	27,332,178	14,519,773	6,951,526	76,466,789
#3	952,099	18,206,462	16,414,875	36,029,794	18,217,640	8,982,087	98,802,957
#4	963,697	19,521,955	17,690,654	38,894,275	19,435,499	9,650,608	106,156,688
#5	914,297	14,567,977	12,886,234	28,107,005	14,849,198	7,132,471	78,467,182
#6	919,820	15,043,510	13,347,411	29,142,476	15,289,437	7,374,266	81,116,921
#7	876,251	11,732,559	10,136,416	21,932,892	12,224,220	5,690,234	62,592,573
#8	1,595,973	19,433,910	16,527,296	35,615,630	20,536,541	9,370,935	103,080,286 (55,183,052)
#9	1,705,357	27,000,335	23,865,294	52,128,083	27,541,398	13,224,047	145,464,514 (77,873,046)
#10	1,584,987	18,825,360	15,938,089	34,289,756	19,974,083	9,061,327	99,674,602 (53,359,852)
#11	1,482,135	14,168,878	11,421,214	24,125,582	15,662,272	6,686,008	73,546,089 (39,372,200)

Note: 1 Figures in brackets are in 1969 dollars

2 Preproduction only

Table 18

Project # 3

Operating Costs

Experiment	Mining	Milling	Overhead	Total
#1	$ 4.875	$ 1.891	$ 1.015	$ 7.781
#2	4.728	1.851	0.987	7.566
#3	4.532	1.810	0.951	7.293
#4	4.478	1.801	0.942	7.220
#5	4.708	1.846	0.983	7.537
#6	4.682	1.840	0.978	7.501
#7	4.885	1.894	1.017	7.796
#8	9.317	3.600	1.937	14.854
#9	8.807	3.452	1.839	14.098
#10	9.367	3.618	1.948	14.934
#11	9.847	3.830	2.051	15.728

APPENDIX II

THE INADEQUATE INFLATION ADJUSTMENT IN THE METALLIC MINERALS ROYALTY ACT

($\$ \times 10^6$)

Royalty rates: 15% and 35%
Normal rate of return: 18%
Processing allowance: 8% of cost of processing assets
Cost of processing assets: $100
U.B. of all assets: $130
Investment Base: $66.67
Depreciation Rate: 20%

		Case 1 (no inflation)		Case 2 (10% inflation) (no indexing)		Case 3 (10% inflation) (full indexing)		Case 4 (10% inflation) (actual indexing)
Revenue:		$200.00	(1.1 x 200)	$220.00		$220.00		$220.00
Operating Costs:		$154.00	(1.1 x 154)	$169.40		$169.40		$169.40
Gross Profit:		$46.00		$50.60		$50.60		$50.60
Depreciation:	(.2 x 130)	$26.00		$26.00	(1.1 x 26)	$28.60		$26.00
Processing Allowance:	(.08 x 100)	$8.00		$8.00	(1.1 x 8)	$8.80		$8.00
Mining Profit:		$12.00		$16.60		$13.20		$16.60
Normal Profit:	(.18 x 66.67)	$12.00		$12.00	(1.1 x 12)	$13.20		$13.20
Excess Profit:		Nil		$4.60		Nil		$3.40
Total Royalty:	(.15 x 12)	$1.80	(.15 x 12) + (.35 x 4.6)	$3.41	(.15 x 13.20)	$1.98	(.15 x 13.20) + (.35 x 3.40)	$3.17

Case 1 is an example of how the royalty would be calculated if there were no inflation. Case 2 shows the royalty calculation with 10 percent inflation and no indexing. Mining Profit is increased by 38 percent and royalties are increased by 89 percent. In Case 3, with 10 percent inflation and full indexing, both Mining Profit and Royalties are increased by 10 percent. Case 4 shows the actual royalty indexing with 10 percent inflation. As with no indexing, Mining Profit is increased by 38 percent. Royalties are increased by 76 percent from Case 1 or 60 percent from Case 3.

Chapter 6

Summary and Conclusions

6.1 Summary

The results of the analysis are graphically summarized in two sets of diagrams.[1] Figures 6.1 to 6.3 inclusive show the relative effects of the legislative and price changes from the viewpoint of a private firm. The figures show in turn changes to the private value, the amount of primary ore, and level of gross investment for each of the projects. Figures 6.4 to 6.7 inclusive show the relative effects of the legislative and price changes from the viewpoint of the province. Shown in turn are changes to the net surplus, production rates, net taxes and royalties, and economic rent.

6.1.1 The Point of View of a Mining Firm

Between 1969 and 1977 the private value of economically viable copper-zinc mine projects in the province have declined from 80 to 90 percent. The income tax and royalty changes have had nearly equal impact on the private value while their combined effect is roughly twice as great as the relative decline in metal prices. The increased rate of inflation in 1977 as compared to 1969 has further reduced the private value from 5 to 10 percent.

The smallest size of project (less than one million total tons of mineral) is made uneconomic to a mining firm by each of the legislative changes and the relative price change. There are changes to both pieces of legislation that could be made which would make the project profitable under 1969 economic conditions. Such changes are desirable because the project

[1] These diagrams use the information provided in the tables of the previous chapter. The vertical axis of each graph is a ratio. For each experiment the ratio is the parameter value over the value determined for the initial experiment.

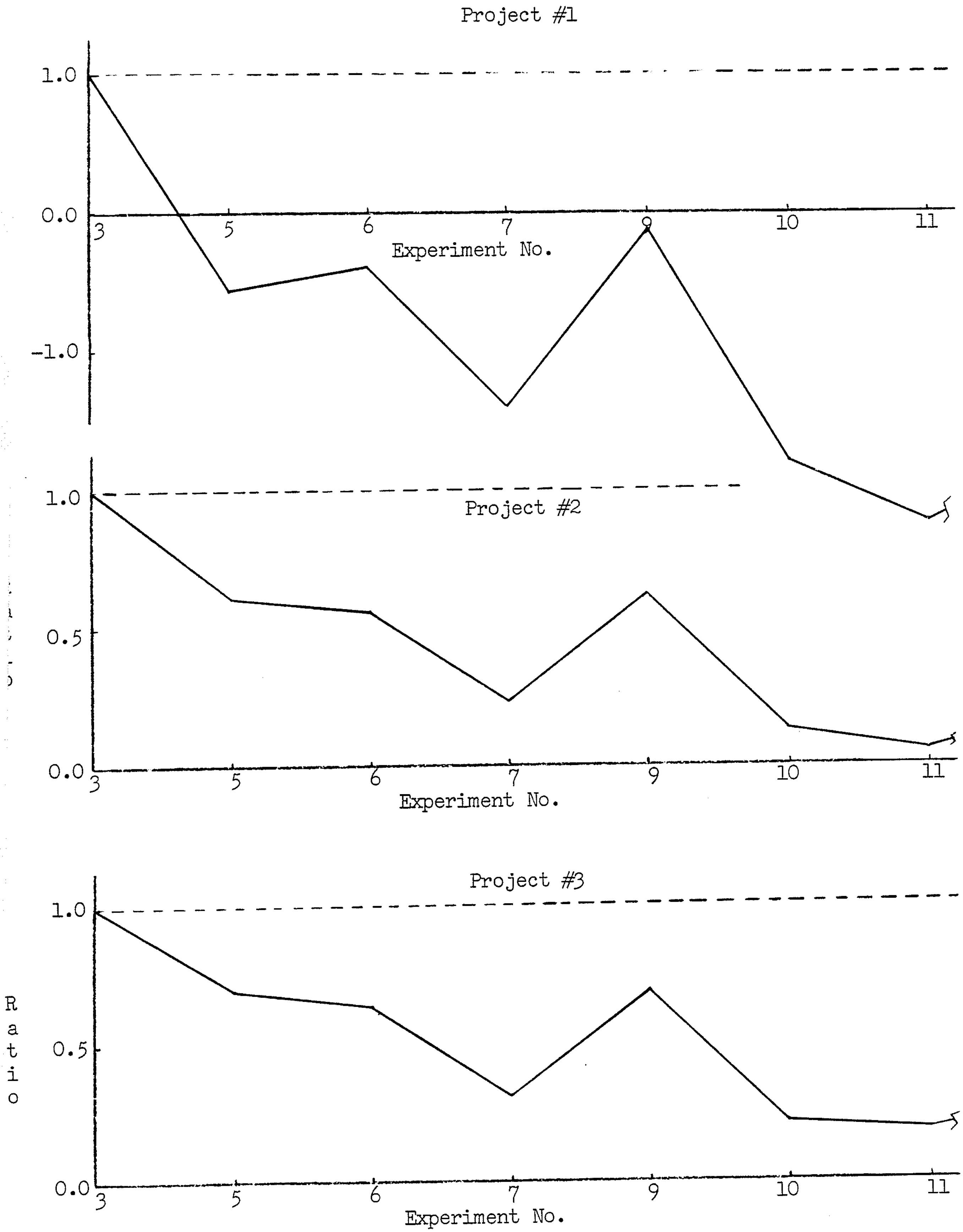

Figure 6.1 Changes in the Private Value of the Optimum Project Since 1969.

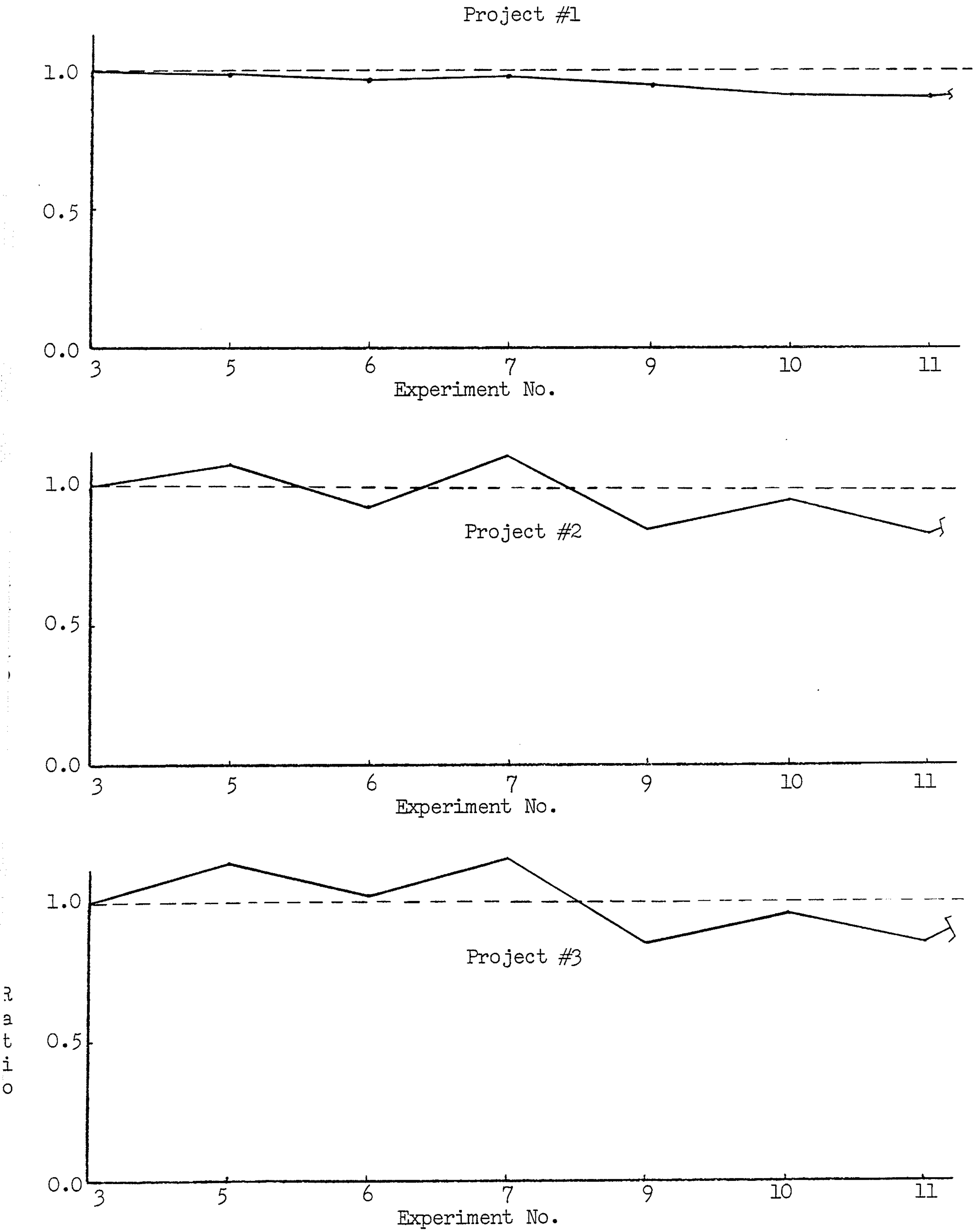

Figure 6.2 Changes in Primary Ore Determined for the Optimum Project Since 1969.

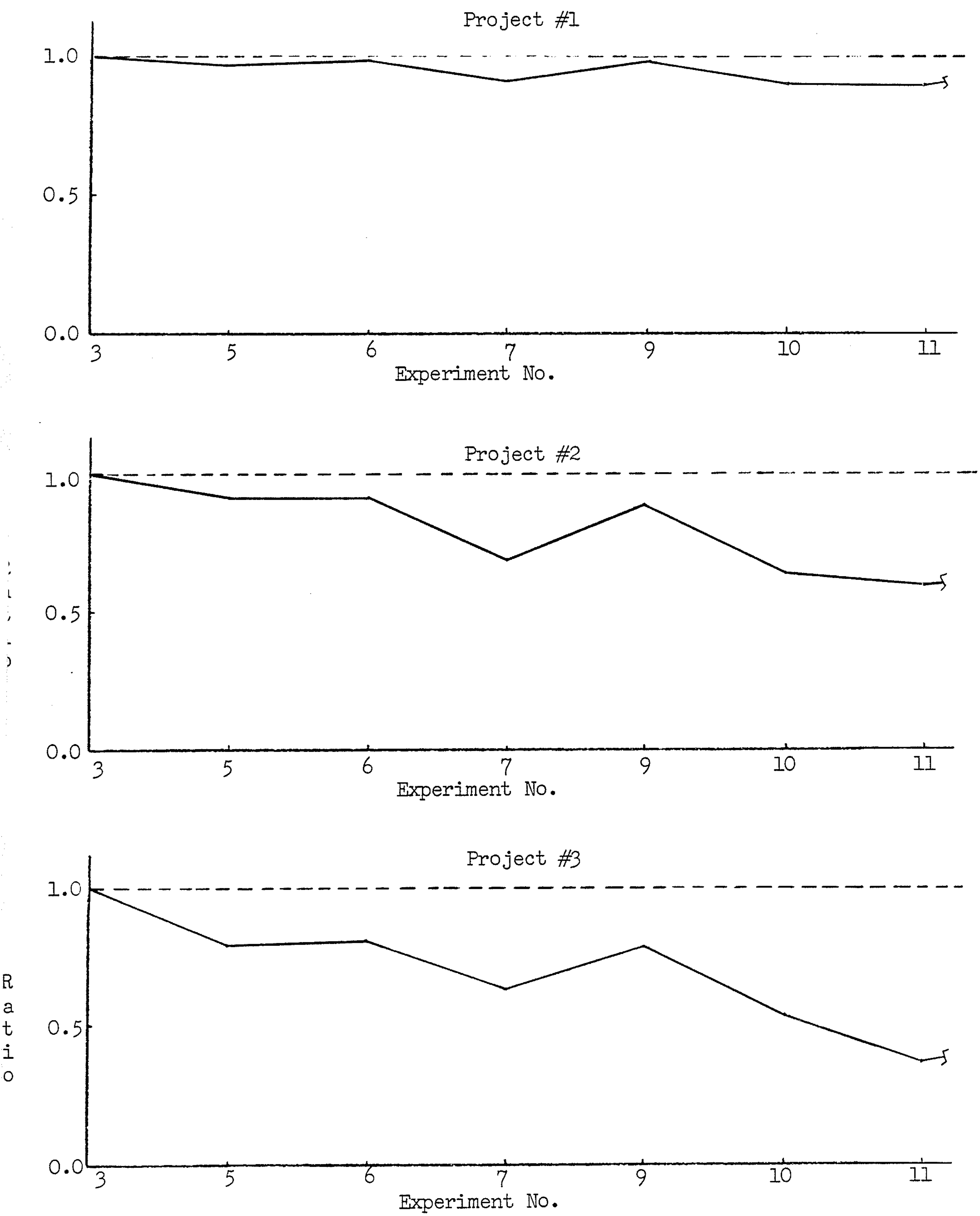

Figure 6.3 Changes in the Optimum Gross Investment Since 1969.

could yield social benefit if undertaken. They would not, however, offset the effect of 1977 economic conditions since, even from the province's point of view, the project is no longer of value.

Although the value of mining projects has declined considerably since 1969, the amount of primary ore available from an economically viable project has changed relatively little. The increased tax and royalty assessments would be expected to reduce the amount of primary ore because of the increased costs but this has been more than offset by the elimination of the three-year tax holiday. With the tax holiday no longer in effect, the incentive to mine most of the ore within the three year exempt period is removed. This, in turn, reduces the mining production rate along with the level of initial investment required. The result is a lower primary ore cut-off grade and more primary ore. On the other hand, lower metal prices have significantly reduced the amount of primary ore as have higher inflation rates.

The tax and royalty changes by themselves could make some marginal projects unprofitable for a private firm. However, this is only a loss to the province only if the province cannot undertake development itself or the tax and royalty legislation cannot be revised so that private development can be encouraged while there are social benefits to be realized.

Finally, gross investment, and the corresponding production rates, for the optimum projects are reduced by the 1977 tax and royalty legislation to nearly one-half the 1969 values. The removal of the three-year income tax holiday is the most important factor in this reduction. The next most significant factor is the introduction of the two-tiered royalty system. Its influence is particularly noticeable when inflation is introduced. The increased profits as a result of the greater inflation leads to a further reduction in production rates and investment in order to avoid or postpone the high assessment on the increased profits.

The relative decline in metal prices has had a much smaller impact on the optimum level of investment for a project. For the two larger projects the price changes have had just over one-half the effect of the legislative changes. The reduced investment is in response to the reduced level of gross profit in conjunction with the tax and royalty legislation in place.

6.1.2 The Point of View of the Province

The potential benefits from investment in mining projects as measured by the social surplus is sensitive to the discount rate used in the evaluation and the tax and royalty legislation in place. Because the supply price of capital for mining investment is well in excess of the private opportunity cost, the province incurs a loss of benefits as measured by the decline in the net surplus. The high value for the supply price of capital reflects a situation where risk is not effectively pooled or the firm, in the manner of a monopoly, can sustain an above average opportunity cost.

The 1969 tax and royalty legislation results in a relatively large cost to the province because the rate of ore production is accelerated well above the socially optimum rate in response to the three-year tax holiday. This situation is largely reversed when the tax holiday is eliminated. When the two-tiered royalty system is introduced production rates decline even further.

The largest loss in benefits occurs when 1977 relative prices are introduced. The smallest of the three sizes of project is no longer able to generate any potential net benefits in addition to being economically unviable for a private firm.

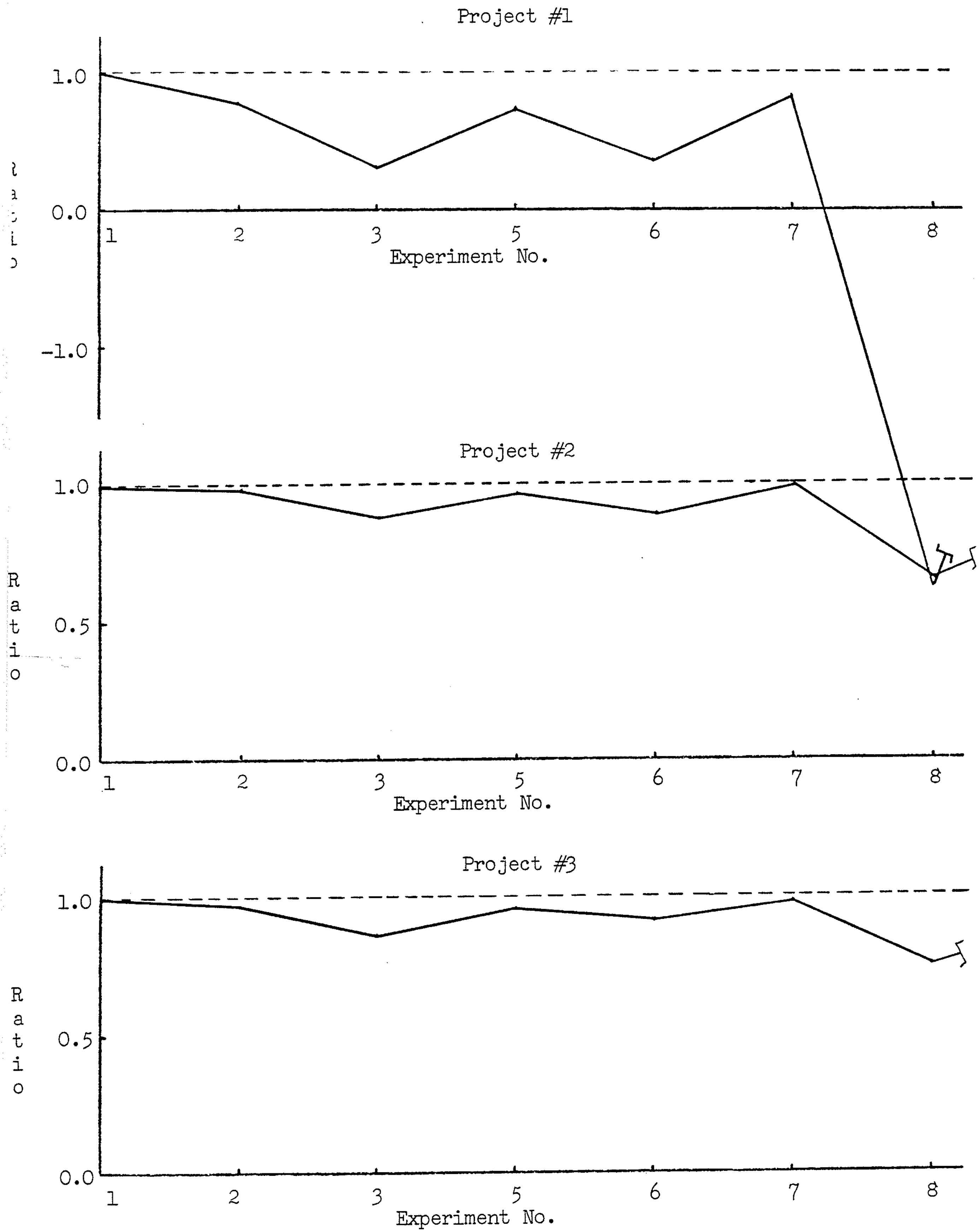

Figure 6.4 Changes in the Social Surplus From the 1969 Maximum.

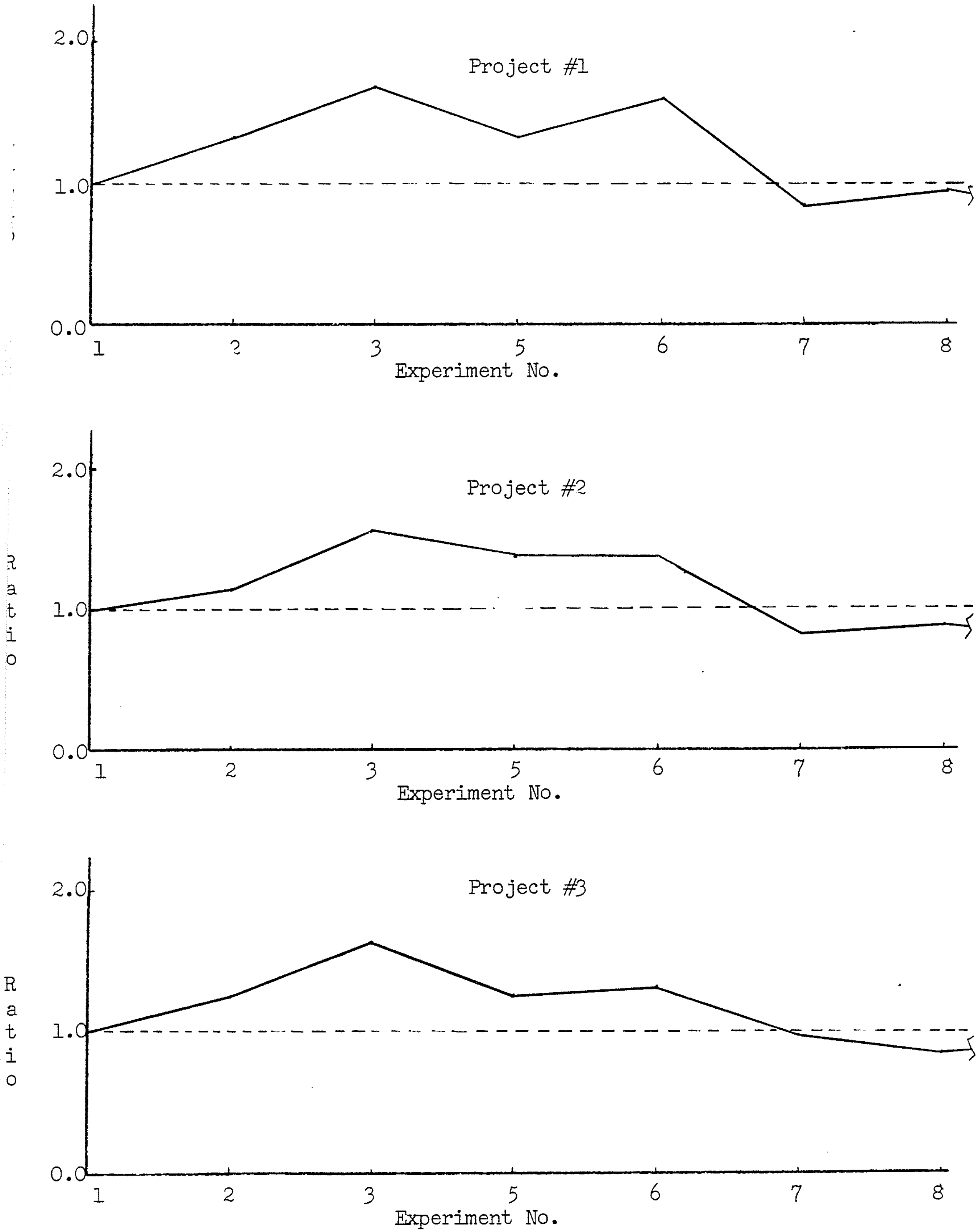

Figure 6.5 Changes in Production Rates From the 1969 Optimum.

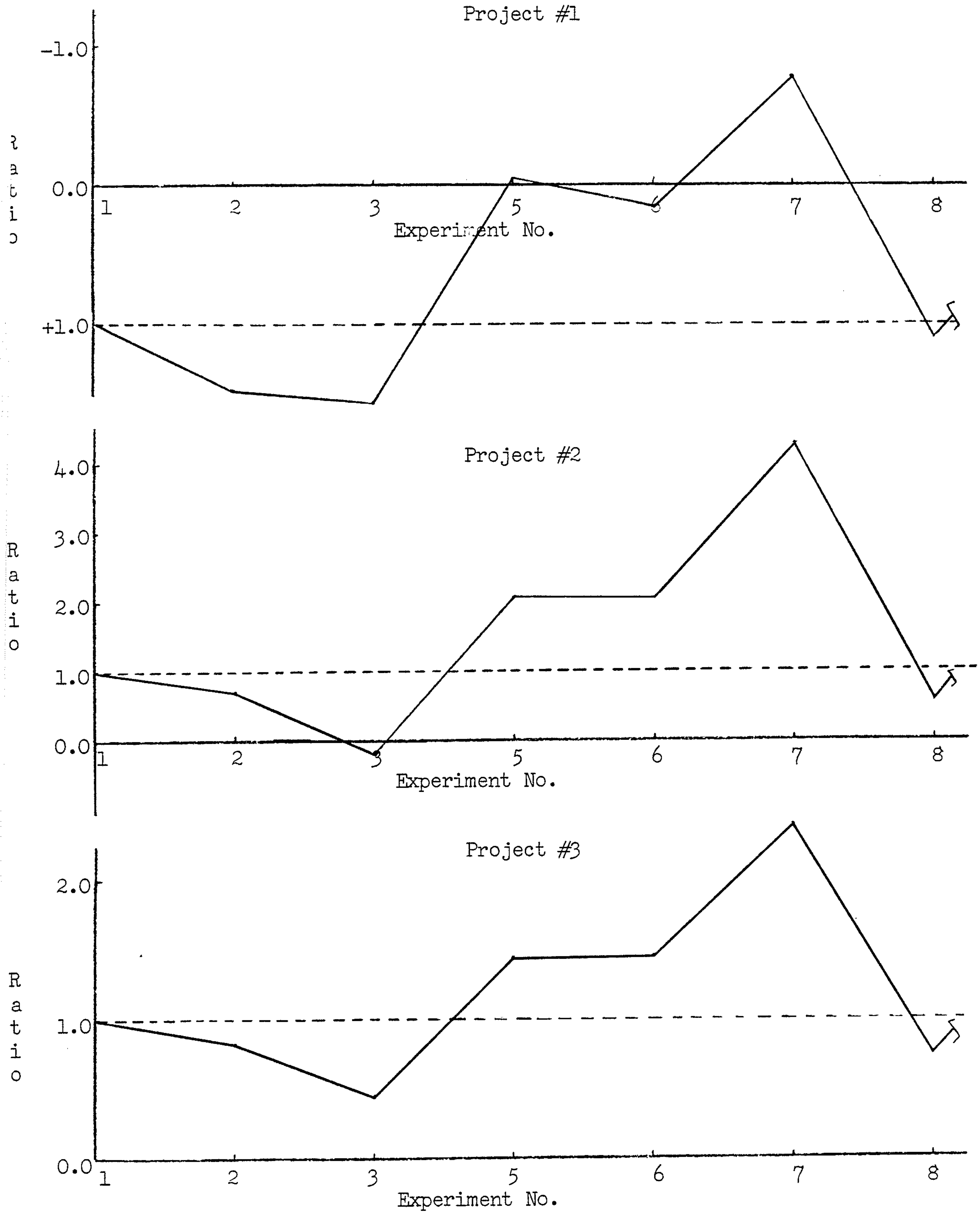

Figure 6.6 Changes in Net Taxes and Royalties From Those Determined for the Socially Optimum Project in 1969.

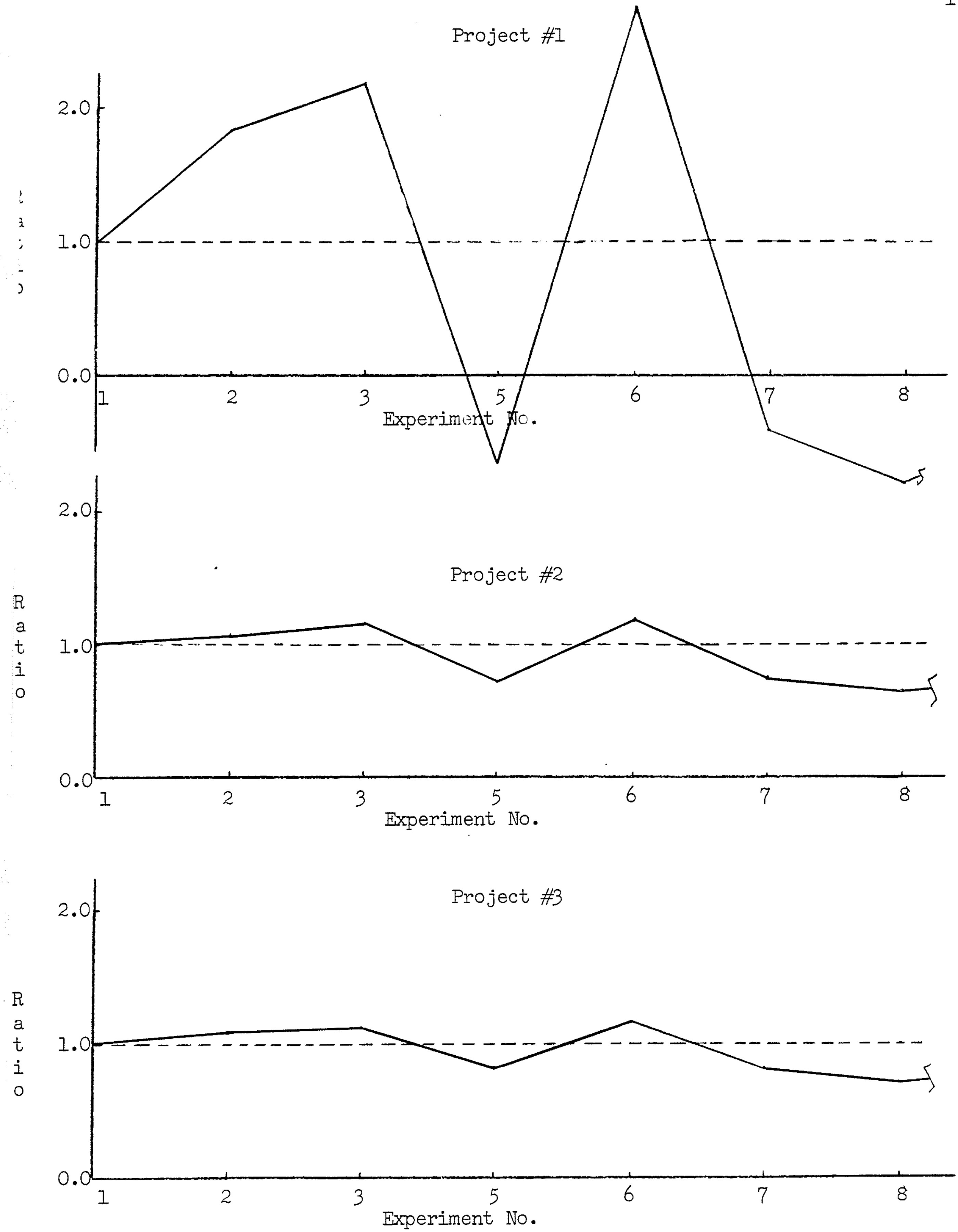

Figure 6.7 Changes in Economic Rent From That Determined for the Socially Optimum Project in 1969.

The social surplus is inversely related to production rates for the values above the socially optimum rate. As production rates increase, the surplus declines; as production rates decrease, the surplus increases. The 1969 legislation raises rates well above the socially optimum values while the combined 1977 tax and royalty legislation reduces it below the optimum rate. The decline in relative prices also results in lower production rates.

Net taxes and royalties from each of the projects was low or negative when the 1969 legislation was in effect. The negative value for the taxes and royalties from the two smaller projects meant that taxes foregone at the time of investment exceeded the present value of revenues received later. The 1977 tax and royalty regimes greatly increased the potential revenue to the province. However the smaller project was no longer economically viable to a private firm and so would not generate any direct revenue (nor, of course, would it incur a net loss).

The relative decline in metal prices in 1977 had a relatively small effect on net taxes and royalties. They were reduced by more than the reduction in the net surplus reflecting some progressiveness in the systems.

The potential economic rent for each project varies with the income tax regime in effect and relative prices. Since the 1969 income tax assessments were quite low, the value of the resource to the owner (the economic rent) was relatively high. The rent declined when the income tax assessments increased but rose when only the royalty assessments increased. The increase occurred because the surplus increased with the decline in production rates. Finally, a substantial drop in the potential rent occurred when 1977 costs and prices were introduced, as would be expected.

6.2 Conclusions

The computer model in this study was used to measure the changing characteristics of copper-zinc projects in the province because of changes in income tax and royalty legislation and changes in relative prices. The study did not simply substitute one piece of legislation for another or one set of prices for another in a project of fixed size and life. Rather, in each case the model determined the optimum size of project needed to develop a mineral deposit. The optimum was either from the point of view of a private firm or from the point of view of the province.

The study showed that the characteristics of the optimum project for a private firm differ considerably from those of the optimum project for the province. There are differences in annual production rates (and level of investment), the amount of ore which can ultimately be mined, and the level of total benefits which can be derived. The differences result because the private firm uses a different discount rate than the province would and because changes to the income tax and royalty legislation imposed elicit a change in the investment decisions of a private firm. That a firm will have a higher discount rate than the province could be a result of inadequate risk-pooling by the firm or an opportunity cost above the risk-free opportunity cost of capital. However, it was shown that the taxes and royalties imposed can partially offset the effects produced by the discount rate. Of course, legislation can also aggravate a problem as was shown when the 1969 income taxes and royalties were in effect. The three-year tax holiday, in particular, had considerable effect.

The analysis also showed that from 1969 to 1977 the private value of copper-zinc projects declined by an average of 80 to 90 percent. Nearly two-thirds of this decline can be attributed to the increased tax and royalty assessments while the remainder is attributable to the relative decline in metal prices and a higher rate of inflation. On the other hand, the potential social benefits from copper-zinc projects have generally been increased by the changes to both the 1977 income tax and royalty legislation. This occurred when the parameter values for the privately optimum project were moved closer to the socially optimum values. These potential benefits, however, are not always realizable so long as development is undertaken by a private firm. This reflects deficiencies in both the income tax and royalty legislation in that assessments are made even when the private value of the project is negative.

The tax and royalty legislation cannot completely offset the adverse effects of a firm using a discount rate above the socially optimum rate. However the legislation can ensure that a project is not made uneconomic for a private firm while potential social benefits exist. This can be accomplished by not assessing taxes or royalties until such time as the initial capital invested plus the minimum acceptable return to that investment has been recovered. The income tax regime of 1977 nearly does this but in an indirect way. All capital invested except preproduction development costs can be recovered as quickly as new income permits. Preproduction development cost recovery is limited to 30 percent of the unclaimed balance, but this plus 30 percent of the unclaimed balance of the other investment can be claimed against existing income. For a company opening a mine for the first time, the 30 percent allowance for investment other than exploration and development can be claimed without earning income. It becomes a taxable loss which can be carried forward for five years. The effect is that deductions equal to the capital cost allowance can be obtained once production commences but with a significant increase in the size of the resource allowance (which is 25 percent of profit after capital cost allowances).

Most of the tax exemption for the basic return to the invested capital is achieved by way of the earned depletion deduction. One-third of the capital invested (except for social capital assets) forms an earned depletion bank which can be used for an earned depletion allowance up to an annual amount of 25 percent of profit before the deduction. Also important is the resource allowance which usually exceeds the royalty deduction it replaces. By this means additional income is exempt from taxation.

The royalty assessments are generally more significant than the income tax assessments where marginal projects are concerned. In any year the depreciation allowance limit is 20 percent of the unclaimed balance (thus the income from a project could be assessed a royalty even though the invested capital may never be recoverable). Also, losses cannot be carried forward as is possible under the income tax act. An approximation of a deduction which would represent a return to the invested capital is achieved by way of the processing allowance. The allowance purports to separate "mining" profit from the "manufacturing" profit so that a royalty would be assessed on the profit from ore production alone. In reality, firms usually do not sell ore. Both for income tax purposes and statistical purposes, "mining" includes all processing up to and including the refined metal stage. Although the distinction between mining and processing profit may have been relevant at a time when processing was taxed in the same manner as manufacturing, this is no longer the case.

Given the desirability of exempting a return to capital from the royalty assessment, the processing allowance is deficient because it is not neutral between firms of different size and age. Because it is a percentage of the original cost of processing assets it provides the same allowance to assets of any age so long as they are in use. There is no consideration for the possibility that the investment in an old asset may have been recovered from income. It is not neutral between different sizes of firm because investment for the mine assets and for preproduction development is excluded. A company which has a large percentage of its investment in mines receives a proportionally much smaller allowance than a fully integrated company that processes to the refined metal stage. The study also showed that where mining investment alone is being considered the lack of an allowance can mean that the investment could not be privately undertaken even though there may be potential social benefits. One possible change would be to replace the processing allowance with an investment allowance. This allowance would be some percentage of the undepreciated balance of all investment. This would correct the neutrality problems (since it would only be on the undepreciated balance and all investments would be included); it would not discourage investment in marginal mines, and; it would be consistent with income tax act in recognizing that "mining" is the total activity necessary in the production of a marketable mineral commodity (which is frequently refined metal).

Two other changes to the royalty system which would prevent assessments of projects that could be sub-marginal for a private firm would be to (i) allow losses to be carried forward, and (ii) increase the upper limit on the depreciation rate. These changes would not be too significant for a firm operating a number of mines because, at present, if any mine incurs a loss, the income from the other more profitable mines is reduced accordingly. Also, the investment in an unprofitable mine can be recovered from the income of the other mines since all investments are pooled. However, the suggested changes would be important for a single mine project. If implemented, they would also make the royalty system more equitable between large and small firms.

An unexpected deficiency in the 1977 royalty system was identified by the introduction of inflation into the analysis. It was expected that the royalty system would adjust for inflation in such a manner as to maintain a reasonably constant effective royalty rate over time. In practice all inflationary profits are assessed by the system. The reason for this is that two of the deductions used in arriving at "mining profit" are not indexed for inflation. These deductions are the depreciation allowance and the processing allowance. The only indexing occurs with the Investment Base which is used to determine the "normal" level of profit. Recall that the Investment Base is the undepreciated balance of the mining and service assets expressed in current dollars. It is increased each year because of inflation and new investment (which is in current dollars). All the existing indexing will accomplish is to prevent a small portion of the inflationary profit being assessed at the incremental rate should profit levels be normal or higher.[2] To completely offset the effects of inflation, all deductions would need to be expressed in current dollars. On the other hand, if the two royalty rates are replaced by a single rate the need for indexing is much less and would not be desirable any more than the full indexing of the income tax system.

As of 1977 total taxes and royalties actually paid by the mining sector do not appear to be out of line with the average level of taxation in Canada.[3] Furthermore the current corporate income tax structure is much

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[2]This was demonstrated by the example contained in Appendix II to Chapter 5.

[3]Joint Report by Federal and Provincial Officials to Finance Ministers and Resource Ministers, Federal-Provincial Resource Taxation Review, p. 29 and p. 31. The actual royalty rate experienced by the mining companies in Manitoba for the three year period from 1975 to 1977 averaged about 15 percent (according to information provided by the Department of Finance). This is comparable with the level of royalty assessments in most other provinces. However, for a mining firm contemplating investment in a new base metal project, Manitoba's royalty assessments are (as of 1977) the highest in Canada (Mining Association of Canada, MAC Task Force Mine Model Analysis, Manitoba, Toronto, 1978). A reduction in the incremental royalty rate could easily change this, if desired.

improved over what it was in 1969. If fault can be found with the tax and royalty reforms, it is that they were introduced at a time when general economic conditions were worsening. The combined effect of increased taxes and lower profits probably resulted in a more severe turn-down in the investment climate than would have occurred if the tax reforms had been in effect some time before the relative decline in metal prices occurred. Contributing to the severe turn-down would be the over expansion that took place in the industry in the late 1960's when metal prices were high and taxes low.

Since the tax structure is now relatively sound and the base metals industry is being taxed at rate comparable to the rate in other sectors of the economy, it is hoped that any further tax and royalty reforms will not go beyond the minor changes suggested in this study. It would not promote good resource management to revise the systems in a major way with the intent of offsetting the reduced rates of return brought on by depressed metal prices and a high rate of inflation.

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